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Voices for SSL Efficiency 2008

Solid-State Lighting Market Introduction Workshop



Workshop Report

**Solid-State Lighting Portfolio
Building Technologies Program
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy**

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COMMENTS

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1. Introduction and Overview

More than 270 attendees gathered in Portland, Oregon, to participate in the “Voices for SSL Efficiency” Solid-State Lighting Workshop on July 9–11, 2008. The workshop, hosted by the U.S. Department of Energy (DOE), Bonneville Power Administration, Energy Trust of Oregon, Inc., Northwest Energy Efficiency Alliance, and Puget Sound Energy, was the third DOE meeting to explore how federal, state, and private-sector organizations can work together to guide market introduction of high-performance SSL products. This report captures and documents the insights, ideas, and updates on the rapidly evolving SSL market shared among the diverse workshop participants, including representatives from industry, energy efficiency organizations, utilities, and government.



The opening session of the third SSL Market Introduction Workshop in Portland, Oregon, July 10, 2008

Chapter 2 of this report summarizes DOE SSL Portfolio Manager James Brodrick’s overview of DOE market introduction activities, including CALiPER testing, GATEWAY demonstrations, ENERGY STAR, and the Technical Information Network. It also covers the opening interactive tutorials focused on key basic principles of SSL technology.

Chapter 3 of this report details the keynote address given by Alan Ruud of BetaLED, who provided insights on the rapid evolution of LED lighting applications, both outdoor and, more recently, indoor. He highlighted several applications where LEDs have been quick winners, including tunnels, streets, parking lots, and garages.

Chapter 4 discusses the DOE GATEWAY demonstration process in further detail, including results from recent installations and previews of several new projects. This chapter also presents frontline experience and best practices for successful demonstration projects.

Chapter 5 offers details on the DOE ENERGY STAR requirements for SSL products, including the process for product qualification, online submission, quality assurance, and marketing opportunities. **Chapter 6** covers LED measurement and testing, including the latest CALiPER test results and key trends.

Chapter 7 looks at understanding product commercialization issues and overcoming barriers that slow widespread adoption of SSL. It includes an introduction to the new NGLIA/DOE initiative on product quality, perspectives of lighting designers from the March 2008 *Lighting Designer Roundtable*, and discussion of a new DOE study on energy and environmental aspects of SSL manufacturing, use, and disposal.

Chapter 8 reports on several new national competitions that heighten awareness and promote adoption of high-performance SSL products, including the *L Prize*, *Lighting for Tomorrow*, and *Next Generation Luminaires*. This chapter also covers the role of utilities in shaping the *L Prize* competition and the collective market pull of utility support for the winning products.

Chapter 9 focuses on what utility and efficiency program managers can do to prepare for high-performance SSL products, ranging from incentives to product demonstrations to taking advantage of involvement in DOE SSL partnerships. **Chapter 10** details next steps for DOE market introduction activities.

All workshop materials and reports referenced in this document can be found on the DOE SSL website at www.netl.doe.gov/ssl.

2. Tutorial Session

2.1 Introduction and Update on DOE Market Introduction Activities

James Brodrick, U.S. Department of Energy

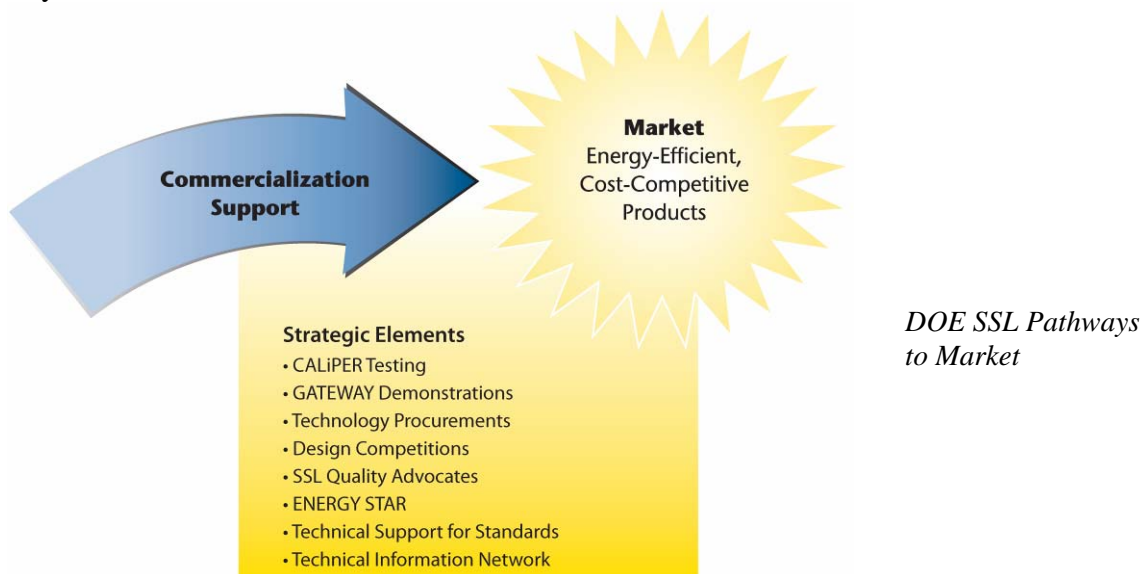
James Brodrick opened the first day of the workshop with a brief overview of existing DOE market introduction strategies, including CALiPER testing, GATEWAY demonstrations, ENERGY STAR, and the Technical Information Network, as well as new pathways including the new *Next Generation Luminaires* and *L Prize* competitions, market studies and technical evaluations, and SSL Quality Advocates.



James Brodrick, DOE SSL Portfolio Manager, welcomed 270 participants and briefed them on DOE market introduction strategies.

The rapid pace of SSL advances – coupled with a growing awareness of how crucial energy efficiency is to our national economy and our energy and environmental future – has led to the swift market introduction of numerous SSL products. Experience shows that intelligently managing the market introduction of new technology is vital to long-term success.

“We now have 10 related programs in market introduction,” Brodrick stated, “giving us very good insight into what is going on in the market, how and where the technology fits in, and what’s coming next. All these elements are focused on bringing SSL into the market in an orderly way with a message of quality, to ensure that SSL comes on – and stays on – the market.”



DOE's comprehensive national strategy to push SSL technology and the market to the highest efficiency and the highest lighting quality continues to center on the crucial aspects of testing, through the CALiPER program, and demonstrations, through the GATEWAY demonstrations. CALiPER testing has proven that no matter the efficiency of the LED array, the overall quality of the entire fixture is based on a combination of key component factors. GATEWAY demonstrations bring together industry partners and other SSL stakeholders to provide real-life experience and data on state-of-the-art SSL product performance and cost effectiveness. Many demonstrations are in the works, Brodrick reported, with talks now underway involving retail giants such as Walmart, Target, and Whole Foods Market, all members of the newly launched DOE Retailer Energy Alliance (REA). Among other ideas, initial REA discussions include exploring SSL parking lot lighting demonstrations through the GATEWAY program.

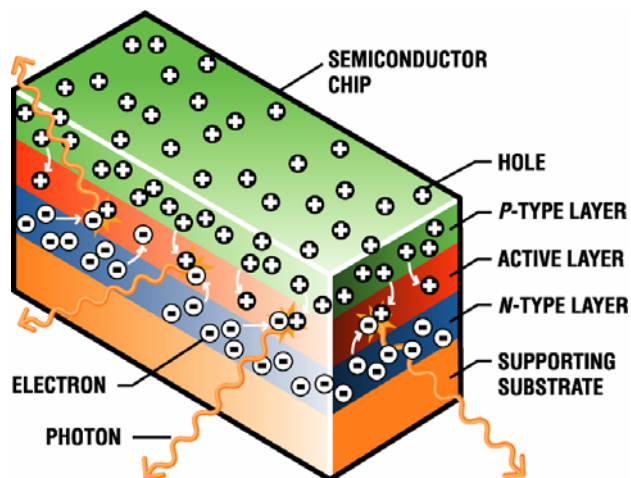
Describing several new initiatives, Brodrick announced a study on the *Life Cycle Analysis of SSL Technologies* and previewed a voluntary product labeling effort known as SSL Quality Advocates. "I view [the] life-cycle study as an important step in understanding how the advent of solid-state lighting will have an impact on energy consumption, energy and product economics, pollution prevention, and ultimately, environmental decision-making," he stated, adding that the focus will be on a soup-to-nuts assessment of energy and materials costs associated with SSL technology.

SSL Quality Advocates, established jointly by DOE and the Next Generation Lighting Industry Alliance (NGLIA), is an effort to assure that LED lighting, as it reaches the marketplace, is represented accurately. "It is extremely important that early adopters of this technology have a good experience," Brodrick emphasized. "Strong market penetration of LEDs will ultimately result in extremely significant energy savings, as much as 10% of national electricity consumption. Both these efforts get to the heart of DOE's efforts – assuring consumers are presented with quality products."

2.2 What Is an LED Lighting System?

Steven DenBaars, University of California, Santa Barbara

Steven DenBaars, Professor of Materials with the Solid-State Lighting and Energy Center at the University of California, Santa Barbara (UCSB), presented a tutorial on the physics behind how LEDs work, and how they differ from conventional light sources. He explained that a blue LED (used with phosphors to make white light) is a semiconductor that produces light by combining positive and negative charges inside an Indium-Gallium-Nitride (InGaN) crystal. Interestingly, the semiconductor positive charges (holes)



combine with negative charges (electrons) to produce light (photons), which is the opposite flow of a solar cell.

DenBaars described two common ways of generating white light through LED technology. The first uses blue LED and phosphors, and currently has the highest efficacy at 160 lm/W (cool white). It also has the lowest cost, and accounts for 95% of the LED market share. The second method uses multi-chip RGB (red, green, blue) technology, which is 95% of the white LED market share and theoretically results in the best efficiency. However, costs are high, the green LED efficiency level remains low at 80 lm/W, and this method represents just 5% of the LED market.

He explained the difference between lamp efficacy and system efficacy, noting that commercial LED fixtures are unable to achieve laboratory device efficacy levels due to efficacy roll-off or “droop,” fixture design issues, heat sink realities, and losses due to scaling up for mass production.

DenBaars then offered his insights on two distinct applications of LEDs: one at the UCSB campus, the other in an off-grid environment. UCSB recently installed 25 LED street lights on campus as a pilot project, after the chancellor decided to install LEDs “because it just looks safer.” The university expects about a six-year payback. DenBaars also noted the potential power of LED technology for off-grid applications using solar (photovoltaics) as an energy source. He emphasized that regardless of how LEDs are applied, the need remains for further R&D to address issues that impact LED fixture efficacy (versus lamp efficacy). He concluded, “LED chip, lamp, and lighting fixture manufacturers have to work together to help implement the solid-state lighting revolution.”

2.3 Using LEDs to Their – and Your – Best Advantage

Kelly Gordon, Pacific Northwest National Laboratory

Kelly Gordon of Pacific Northwest National Laboratory (PNNL) presented a tutorial on LED applications, explaining that LED technology is advancing so rapidly that next-generation LED products are introduced about every six months. She also offered a snapshot of four LED lighting applications, detailing the current status, benchmarks, product performance, and a checklist of “what to consider” when evaluating recessed downlights, undercabinet lighting, portable desk/task lights, and outdoor area lighting.

Gordon stated that LEDs can save energy and provide high-quality lighting in a growing number of applications, but she cautioned that “as with any newly designed products, there are pitfalls.” She described key characteristics of well-designed LED lighting products such as energy, efficiency, very long life, good lighting quality, and effective color and distribution, adding that special attributes of LEDs include directional flexibility, compact size, breakage and vibration resistance, optical precision, successful operation in cold temperatures, near instant-on, rapid cycling without loss of lifetime, control options, and no infrared or ultraviolet emissions.

Focusing on the importance of matching LEDs with the right applications, Gordon next concentrated on “what you should be looking for and what questions you should be asking.” Providing CALiPER data on comparative *in situ* testing on downlights, she noted that one commercially available LED product tested exceeds CFL efficacy and has light output and color comparable to incandescent, while one PAR-30 replacement is comparable to R-CFLs in output and efficacy. Considering the rapid advance of LED technology, continued improvement in other LED downlight products is expected.

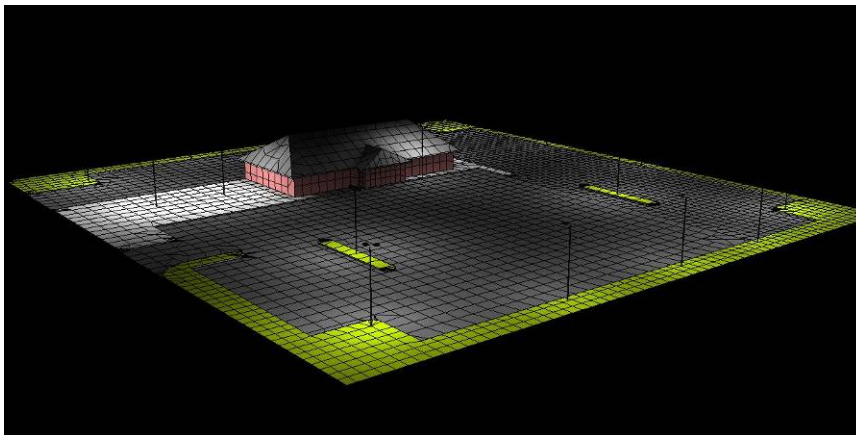
2.4 Measuring LED Performance

Mike Grather, Luminaire Testing Laboratory, Inc.

The workshop’s third tutorial, presented by Mike Grather of Luminaire Testing Laboratory, Inc., focused on LED measurement and how it differs from traditional methods for measuring lighting performance. As Grather explained, conventional lighting sources are usually tested using *relative photometry*: the luminaire is measured, and then the lamp(s) and ballast(s) are removed and measured separately. After that, luminaire efficiency can be calculated, with luminous intensity distribution scaled to candela per rated lumen.

Photometric testing for LED products using *absolute photometry* allows more accurate measurement of the complete LED device performance versus bare lamp performance. Grather explained that “the LED devices are usually difficult to remove from the luminaire, and LED devices will not operate properly without the heat-sinking that the luminaire provides. The thermal environment that the LED devices experience within the luminaire is often radically different from the thermal environment it will experience in its ‘bare lamp’ configuration.”

Grather added that photometric testing allows lighting performance to be evaluated using a number of key metrics, including total luminous flux (lumens), luminaire efficacy (lumens per watt), and luminous intensity (candela). This testing helps predict the performance of the luminaire in its application and also delivers metrics for evaluating the light’s color, providing CCT (correlated color temperature), CRI (color rendering index), and chromaticity coordinates (x, y and u', v').



Photometric testing results can be used to predict the performance of the luminaire in its application.

One tool used for absolute photometric testing is a goniophotometer, which can measure the luminous intensity of the luminaire from specific angles. Another useful tool is an integrating sphere, which can measure the luminaire's color properties. Results include total luminous flux, plus spectral power distribution, chromaticity coordinates, CRI and CCT. Using these tools and test results enables potential buyers to more accurately evaluate LED lighting products.

3. Keynote Address

Alan Ruud, BetaLED

Day 2 of the workshop began with a keynote by Alan Ruud, president of BetaLED, who provided insights on the rapid evolution of LED lighting applications – the challenges, opportunities, and strategies for success.

“It’s an exciting time – probably the most exciting time I’ve seen since I’ve been in this industry,” Ruud stated, noting that SSL applications are accelerating at a rapid pace, from the original architectural applications to outdoor applications (in the last 12 months) to indoor applications (in the last few months). He highlighted several applications where LEDs have been quick winners, including tunnels, streets, parking lots, and garages.



LED street lights in use on Fayetteville Street, in Raleigh, North Carolina

“High-quality LED installations exist today – seeing is believing on how good and valuable LED lighting can be,” Ruud continued. He showed attendees a series of installation photos that clearly demonstrate the benefits of LED lighting beyond energy savings. He also added that evaluation of LED fixtures is simple and predictable if you have the right information.

Comparison Chart										
TRADITIONAL LAMP SOURCES						LED				
Lamp Source	Aperture	Optical Efficiency	Initial Delivered Lumens	Life (Hours)	System Watts	Number of MCs	Initial Delivered Lumens	Life Hours - L70	System Watts	Energy Savings %
250 Quartz	6-inch	70.6%	3,424	2,000	250	12	4,000	50,000	99	60%
70 MH ED17	6-inch	49.3%	2,662	16,000	94	9	2,475	100,000+	48	49%
2-26 PLT	6-inch	56.6%	1,935	12,000	55	6	1,650	100,000+	33	40% 23%*
100 A19	4-inch	41.8%	652	750	100	3	825	100,000+	17	83%
50 MR16	4-inch	90.0%	826	3,000	59	3	825	100,000+	17	71%

Chart comparing the performance of LED with traditional sources for indoor applications

Ruud declared that LEDs are “ready for prime time,” but warned that it is “incumbent on everyone to not settle for a luminaire that does not perform to your standards.” He emphasized that the key to LED specification and evaluation is to look for the same criteria you would seek for traditional sources:

- Photometric performance data (using the new LM-79 standard)
- Energy consumption (efficacy) data
- Aesthetics
- A warranty you can trust

Next, Ruud discussed key differences in LED performance evaluations, noting that lifetime and light loss factor (LLF) ratings for LEDs are still predictable and no longer tied to the lamp, but to the luminaire in the actual environment. “LM-80 in combination with ENERGY STAR,” he said, “will deliver standards to rely on in comparisons.”

Ruud ended his keynote by emphasizing that “LEDs really are the best solution for many lighting applications. This is a win/win, not a zero-sum game.” He again reminded the audience not to accept inferior products, and advised them to have a clear understanding of the technology behind the product.

Following his presentation, Ruud took questions from the audience, first answering a query regarding the longer life of LED luminaires and how that might impact lenses becoming dirty and thus affecting lumen performance. “[There are] two points I want to make here,” Ruud answered. “First, pressure washing every 18–24 months in some outdoor applications is effective. The second and more important point is that with HID products especially, we are dealing with tremendous thermal gradients of warm-to-cool, resulting in a lot of mineral deposits on lenses due to the heat of condensation. With LEDs, we’re dealing with very cool sources where I don’t anticipate the same lumen depreciation.”

When Ruud was asked if he had any experience with the effect of lightning damage on power supplies, he replied that damage to supplies “is controllable, using special built-in surge protectors. Not to survive direct hits, but transient on-the-line lightning – they will survive that.”

Finally, Ruud was asked if he thought it would be wise to wait, given how fast LED technology is moving. Ruud answered, “What you’re asking is – are we so early on this that waiting makes sense? Where are we on the curve? I can tell you that we are not on a steep curve – the curve is over. We’re shipping the same chip packages today that we were shipping last October. We see the curve flattening. Cost may come down, but we’re well beyond the beginning. Why not start saving energy now? Why not start saving maintenance now?”

“The analogy I use,” he concluded, “is laptop computers and flat-screen TVs. Why not wait until performance improves and price comes down? Because you want to take advantage of the benefits now – that is the key to why we’re here today.”

4. Solid-State Lighting Demonstrations

4.1 DOE GATEWAY Demonstration Program

Bruce Kinzey, Pacific Northwest National Laboratory

PNNL's Bruce Kinzey started the presentation with an overview and general observations on the GATEWAY demonstration process. GATEWAY demonstrates new SSL products that meet three criteria – saving energy, matching or improving the existing illumination, and offering real economic value to users – and then to widely promote successful products. What the GATEWAY demonstrations do not do, he emphasized, is identify the “best” lighting investment for a given user or application, from among all possible alternatives.

Noting that every project is different and many potential projects do not reach fruition, Kinzey reviewed the common steps each must undergo, including identification, testing, matching, installation, measurement, feedback, evaluation and, finally, documentation and reporting.

Previewing the results of the Oakland, California, street lighting demonstration, Kinzey observed that technically, the Oakland project was a resounding success. However, atypically low maintenance estimates for the incumbent lighting affected the city's final assessment of the LED lighting demonstration. Kinzey then offered results from the Federal Aviation Administration's William J. Hughes Technical Center in Atlantic City. The table below illustrates the FAA's demonstration results, showing that a simple payback of 3–7 years is possible.

	Existing 70W HPS	New 3-bar Luminaire	Optional 2-bar Luminaire
Average illumination levels	3.54 fc	3.63 fc	2.42 fc
Minimum illuminance	1.25 fc	1.90 fc	1.27 fc
Max/Min ratio	6.04:1	2.68:1	2.68:1
Total power draw	97W	72W	48W
Energy savings per luminaire	N/A	114 kWh/yr (26.8%)	215 kWh/yr (50.6%)
Simple payback if HPS are at end of life, includes maintenance savings	N/A	7 yr	3 yr

Demonstration results at FAA's William J. Hughes Technical Center in Atlantic City show simple payback of 3 years using 2-bar luminaires and 7 years using 3-bar luminaires.

While 3-bar luminaires were used in the demonstration (center column), Kinzey stated that if 2-bar model luminaires had been used (right column), simple payback would have dropped to three years, with more than 50% energy savings. “This was a very strong technical success,” Kinzey said. “Also, we received positive feedback from both inside FAA staff and the security forces patrolling the grounds after hours. They wanted us to

replace all the lighting.” More detailed results may be found in the full demonstration report at www.netl.doe.gov/ssl/techdemos/htm.

Kinzey next previewed several new GATEWAY demonstration projects under way, including roadway lighting for the new St. Anthony Falls Bridge in Minneapolis, freezer case lighting for Albertsons Foods, downlights and undercabinet luminaires for Northwest Green Builder homes, and multiple potential parking lot applications through the DOE Retailer Energy Alliance.

While all these demonstrations are significant, Kinzey characterized the Minneapolis bridge reconstruction project as “one that will establish whether or not LEDs are ‘ready for prime time.’ And an especially interesting aspect of this demo,” he continued, “is the longitudinal study – three of the luminaires will remain on the bridge for three years, after which they will be retrieved, sent back to the same laboratory and retested. We should get a very precise estimate of how these luminaires have fared. To my knowledge, this kind of longitudinal study has not been done anywhere yet, at least in an official capacity.”

Kinzey concluded his remarks by reiterating the immense interest in the marketplace in solid-state lighting right now. “The user community is still forming their opinions on this technology, so what we do will be critical,” he asserted. “Luminaire efficacy is different from source efficacy, so we must stop ‘apples to oranges’ comparisons. Efficacy is only part of the energy efficiency picture; we must also ask, ‘How effectively are the lumens used?’ and consider economic life-cycle costs such as maintenance rather than first-costs only in economic analyses. Finally, we must band together and remain vigilant against ill-suited demonstrations. No matter how fuel efficient your vehicle is, if you’re headed in the wrong direction, you’re still wasting gas!”

4.2 Results – Performance Data and Economics from the Oakland Street Lighting Demonstration

Tyson Cook, *EnergySolutions*

The next member of the panel, Tyson Cook of *EnergySolutions*, shared performance data, economic results, and user feedback from the DOE GATEWAY demonstration of street lighting in Oakland, California. According to Cook, the primary objectives were to determine product viability and energy savings; examining economic feasibility was a secondary objective. *EnergySolutions* served as monitoring consultants for the demonstration, which brought together the Emerging Technologies Division of Pacific Gas and Electric Company, DOE, and the Department of Public Works of the City of Oakland.

In the demonstration, 15 100-watt high pressure sodium (HPS) luminaires were replaced with BetaLED’s The Edge™ luminaires. The study found that LEDs were a viable alternative for 100-watt high pressure sodium fixtures, offering an estimated annual cost savings of 44–50% and greater perceived visibility despite reduced average illumination. Cook noted that high upfront costs can lead to long simple paybacks, which are sensitive to the host site’s estimated maintenance savings.



A direct comparison of street lighting shows the superior color temperature and rendering of LED (top) over HPS (bottom).

One aspect of determining quality, Cook explained, is color temperature and rendering, dramatically illustrated by the two photos above, each depicting the same street area. The top photo shows the area illuminated by HPS lighting, while the bottom photo is illuminated by LEDs.

Cook also noted that user surveys of area residents showed that a majority indicated a clear preference for the LEDs and noticed better nighttime visibility.

The main economic factors considered for the demonstration included energy cost, maintenance cost, and upfront cost or initial investment. In terms of power measurements to determine energy costs, Cook reported a savings of 43.4 watts or 178kWh/year.

“In addition,” Cook said, “a very important factor here is the rated life of these fixtures” – essentially, how long it takes before they have to be replaced. He continued, “HPS fixtures are rated at about 30,000 hours – or seven years – while LEDs, in contrast, are estimated at about 100,000 hours – or about 24 years, with the caveat that testing standards for this predicted lifespan are still under development.”

Ending his presentation, Cook urged participants interested in additional information to seek out the full demonstration report at www.netl.doe.gov/ssl/techdemos.htm.

4.3 Considerations – Planning for SSL Demonstrations, from Casinos to Community Centers

Daryl DeJean, Emerging Technologies Associates, Inc.

Daryl DeJean of Emerging Technologies Associates, Inc. concluded the panel presentation by offering a look at planning for SSL demonstrations. He offered insights on customer perspectives and needs, which he defined as accurate product data sheets; reliable technical information such as independent test results or ENERGY STAR qualification; material safety data sheets; testimonials and other assessment results; warranties; and a local installation to tour where possible.

DeJean noted that SSL demonstrations are “very application-specific, customer-specific, and segment specific – one hat does not fit all. What the customer wants, essentially, is to be on the inside looking out – they want you to put yourself in their shoes.” Those who participate in planning or implementing demonstrations want to listen and be heard, be educated toward informed decision-making, and demonstrate on-site, real world, side-by-side comparisons of the application. “Seeing is believing,” DeJean said, “and they want to see proof.”

Next, DeJean outlined customer considerations for possible demonstration projects (at right), stating that “our job is to take the complex and make it simple. Customers want good data and they want to know that this technology is reliable.”

DeJean concluded by urging attendees to “keep the explanations customer-focused, using their lingo,” emphasizing again that “the message we communicate will determine the movement we gain.”

In the question and answer session following the panel’s presentations, a participant asked Bruce Kinzey about the maintenance costs for the Minneapolis bridge project. Kinzey replied that the numbers are not yet available, since the evaluation has not been conducted. He added, however, that anticipated avoided maintenance costs were a key selling point for the demonstration. “You can imagine,” he said, “the difficulties of going out and changing lights on an interstate bridge – the huge insurance costs, lane closures, and the like.”

A questioner from the City of Seattle pointed out that his city is seeing lower costs for the purchase of replacement HPS luminaires than those cited by Tyson Cook. Cook responded by clarifying that his

Customer Considerations

- **Real value**
 - Economics – life cycle cost vs. first cost- cost effectiveness
 - Productivity improvement
 - Maintenance
 - Environmental
- **Comparison**
 - Side-by-side in application
 - Replacement potential
- **Applications**
 - Seeing beyond
- **In situ evaluation**
 - Product performance
- **Impact on operations**
 - Profitability
 - Maintenance
 - Refinement of lighting strategy
- **Customer acceptance**
 - The experience
 - Understanding
- **Energy and sustainability strategy**
 - Early adopter and leadership position in market
 - GHG impact
 - Green Procurement

report's costs "take into account installation by unionized electricians, not just the fixed cost of the fixture. And we included those costs in both estimates."

A final questioner asked the panel if they have taken into account that relamping LED products might really involve buying a whole new fixture. In response, DeJean observed that, in the case of overhead fixtures, "assuming a 20 to 25-year life, it's actually possible that LED luminaires will last the same length of time where they would normally be replacing the fixture."

5. ENERGY STAR® for SSL

5.1 DOE ENERGY STAR Criteria for SSL

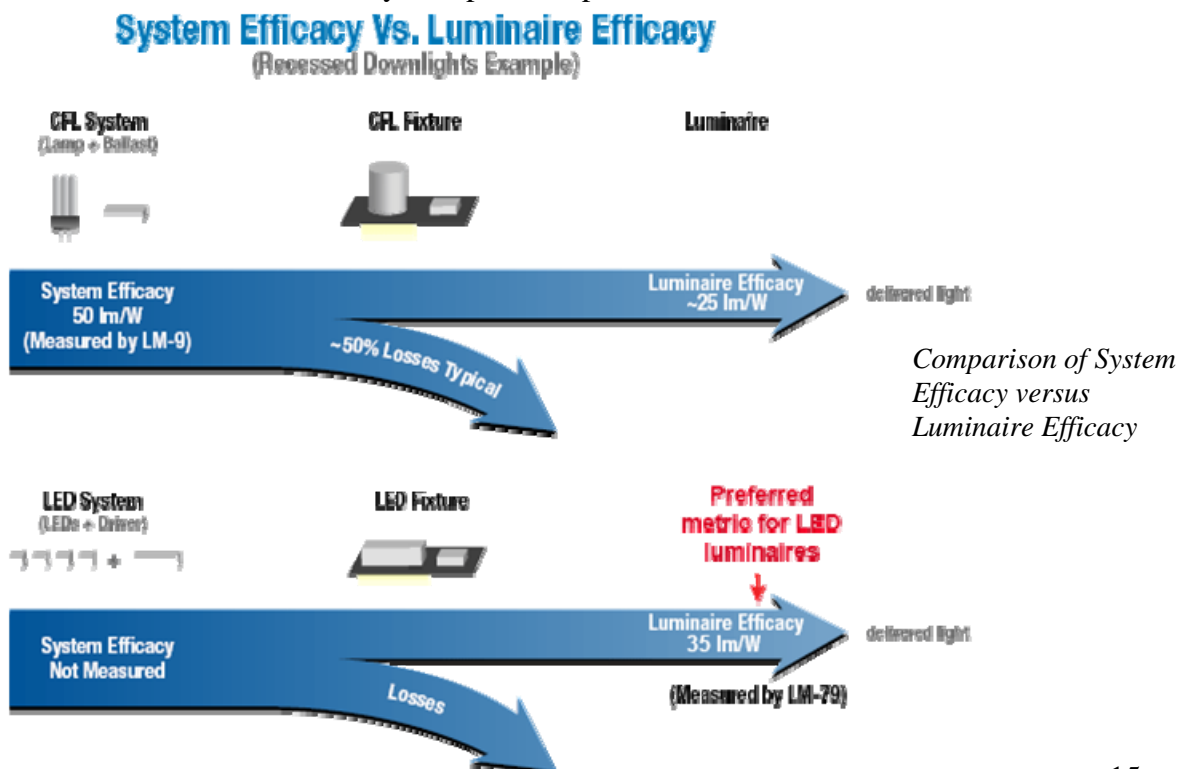
Richard Karney, U.S. Department of Energy

Session 2 began with an update on the DOE ENERGY STAR program for SSL. Richard Karney of DOE shared the Department's concerns about the competing ENERGY STAR criteria for residential luminaires issued by the U.S. Environmental Protection Agency (EPA), stating that significant conflict/overlap exists between the two criteria. Karney said, "There can only be one set of ENERGY STAR criteria for SSL, and the DOE criteria stand as the valid guidance for SSL." Karney affirmed that DOE is working to resolve the issue as quickly as possible.



Richard Karney, DOE, reviews the current status and time line for the first ENERGY STAR products in September 2008. Seated, left to right, Derek Greenhauer, D&R International, and Jeff McCullough, PNNL.

Karney offered a comparison of the two criteria, noting that DOE maintains a focus on luminaire efficacy and uses a phased approach to first introduce the consumer to select applications where SSL products can meet or exceed expectations until a wider range of quality products is available. DOE's criteria require that products achieve minimum light levels and are based on industry-accepted test procedures.



Karney reiterated DOE's commitment to maintaining an open process with stakeholder involvement and continued focus on product quality, using standards and test procedures developed and recognized by industry organizations such as IES, ANSI, and NEMA.

Next, Karney reviewed the current status and timeline for the first ENERGY STAR SSL products to arrive on the market starting September 30, 2008. Seven Category A niche applications will be the first SSL products eligible to qualify for the ENERGY STAR label. Karney explained that ENERGY STAR qualification is important to the SSL market, to differentiate quality products from poor products. DOE intends to put SSL in a position to succeed with consumers, and will initially focus on well-defined applications that meet and exceed expectations. This will ensure quality products, satisfied customers, and more successful market acceptance than with CFLs.

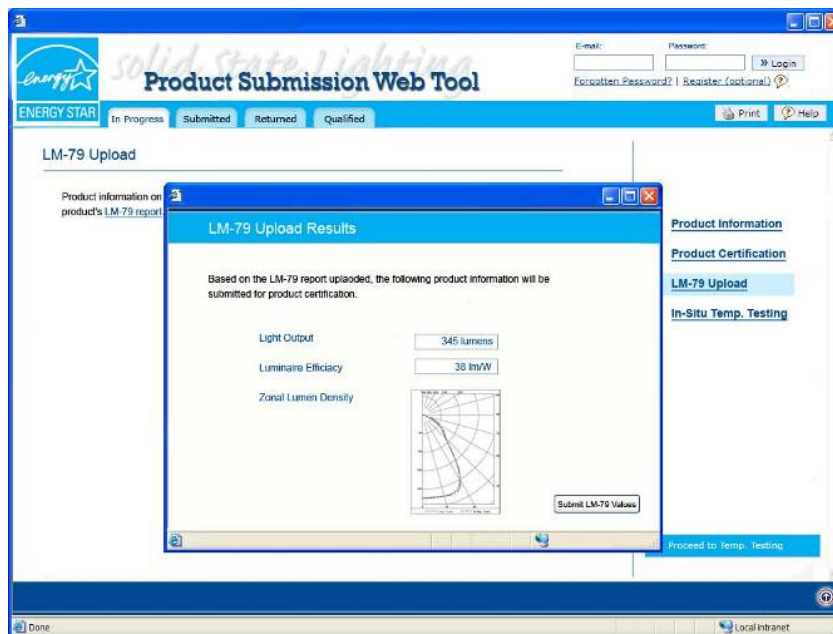
Finally, Karney offered an overview of the DOE ENERGY STAR requirements for CCT, CRI, uniformity, thermal management, power supply, warranty, and other key requirements, plus an update on the status of related test procedures (including the soon-to-be-released LM-80 procedure). He concluded with a look to the future, discussing phase 2 of the ENERGY STAR SSL program, which will introduce Category B in approximately three years. Category B will apply to all types of SSL products and require more rigorous performance targets (70 lm/W). In the meantime, to keep pace with rapid SSL technology advances (improvements in LED chips, thermal management, fixture design), DOE plans to expand Category A applications and to develop a ratcheting schedule to gradually move efficiency targets from Category A targets to Category B targets. DOE looks forward to the continued involvement of the lighting industry in the development of these plans.

5.2 Launching the ENERGY STAR SSL Program

Derek Greenauer, D&R International, Ltd.

Derek Greenauer of D&R International presented details on the ENERGY STAR qualification process and how to become an ENERGY STAR partner. A manufacturer's guide and online product qualification process are currently in development and will be available in sync with the ENERGY STAR SSL program launch. To become an ENERGY STAR partner, a manufacturer must complete the online submission form and sign a voluntary, non-binding partnership agreement.

Greenauer also discussed testing requirements, quality assurance, and other program elements designed to provide end-users with a high level of confidence in labeled products. ENERGY STAR partners will have access to ready-made materials, including an e-newsletter, forums for stakeholders, programs on the Web, and a wide range of customizable tools and resources (e.g., a partner resource guide, frequently asked questions (FAQs), product profiles, media outreach and support, and sales data). Next, Greenauer described consumer outreach activities, noting that initial targets for the residential market will be early adopters attracted by new technology, while lighting designers will be the initial target for the commercial market.



*ENERGY STAR
online product
submission tool*

Once the DOE ENERGY STAR SSL program launches, additional resources – a product finder, rebate finder, savings calculator, and consumer education tools – will be available on the ENERGY STAR website.

5.3 ENERGY STAR SSL – Keeping Pace with Technology Advances

Jeff McCullough, Pacific Northwest National Laboratory

Jeff McCullough of PNNL wrapped up the ENERGY STAR session with details on DOE’s plans to keep pace with rapid technology advances. DOE’s two-phased approach allows early participation of a limited range of Category A products that can meet and exceed customer expectations. Category B sets more rigorous performance targets with an eye toward future products, recognizing that steady improvements in LED chips, better thermal performance, and other advances will lead to higher-quality products. McCullough noted, “It is critical to provide consumers with meaningful information in this immature market, where they have limited understanding of this new technology.”

McCullough elaborated on DOE’s plans to add new product applications to Category A, including street and area lighting, parking garage lighting, cove lighting, ceiling lighting, replacement lamp applications, display and accent lighting, and wall-wash applications. DOE will benchmark existing technology performance using CALiPER testing, evaluate cost effectiveness, establish draft performance criteria to ensure high-quality products, and provide opportunities for stakeholder review and comment.

The proposed ratcheting of efficacy targets over time will enable the ENERGY STAR criteria to keep pace with technology improvements. DOE will continue to engage industry for feedback on new applications and ratcheting plans in the coming months. To keep up on DOE ENERGY STAR SSL program implementation details and future plans, visit www.netl.doe.gov/ssl/energy_star.html.

6. LED Measurement

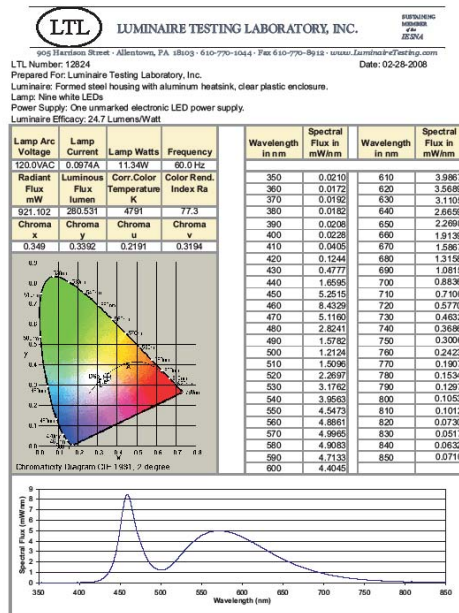
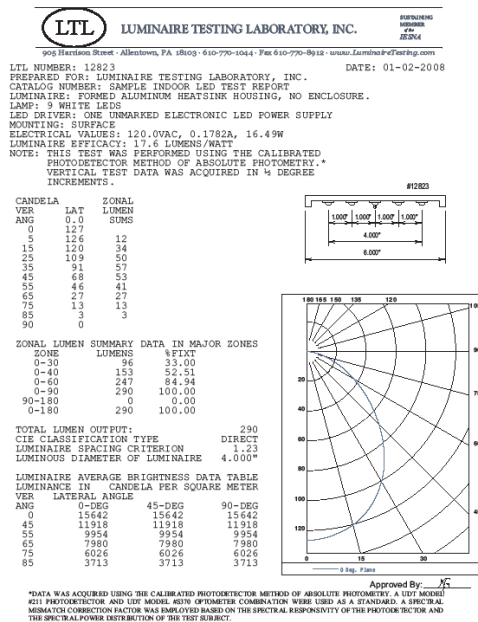
6.1 Testing Procedures – LM-79, LM-80, and More

Mike Grather, Luminaire Testing Laboratory, Inc.

To begin the afternoon session, Mike Grather took the podium to elaborate further on LED measurement, and reviewed new test procedures for measuring LEDs: ANSI C78.377-2008, Specifications for the Chromaticity of Solid-State Lighting Products; IES LM-79-2008, Electrical and Photometric Measurements of Solid-State Lighting Products; and IES LM-80, Method for Measuring Lumen Maintenance for SSL Light Sources (expected in 2008).

Grather explained why traditional methods for measuring lighting performance are not appropriate for SSL. Traditional methods are based on *relative photometry*, where the luminaire is measured and then the lamp(s) and ballast(s) are removed and measured, enabling calculation of luminaire efficiency. This method is inappropriate for SSL products, in which LEDs are often integrated in the fixture in ways that make it difficult or impossible to remove them, and accurate measure of luminaire performance cannot be obtained when LEDs are separated from their heat sink. Instead, the LM-79 test procedure developed by IES uses *absolute photometry* to enable more accurate measurement of the complete LED luminaire performance.

Grather described the testing equipment used to measure LED performance, explaining that a goniophotometer and integrating sphere test eleven aspects of performance, including total luminaire efficacy (lumens per watt), chromaticity coordinates, CRI (color rendering index), and CCT (correlated color temperature). Absolute photometric testing determines SSL performance in an objective, thorough way, providing potential buyers with meaningful information and an opportunity to compare apples to apples.



Sample test results from a goniophotometer and an integrating sphere

6.2 DOE CALiPER Program – The Latest Test Reports and Analysis

Mia Paget, Pacific Northwest National Laboratory

Mia Paget of PNNL followed with the latest results and analysis from DOE's CALiPER program. CALiPER tests commercially available SSL products for the general illumination market. To date, in five rounds of testing, DOE has tested more than 100 products.

CALiPER results inform industry test procedures and standards development, while discouraging low-quality products and reducing SSL market risk due to buyer dissatisfaction from products that do not perform as claimed. CALiPER testing is conducted at multiple independent laboratories, and DOE assembles, analyzes, and shares results.

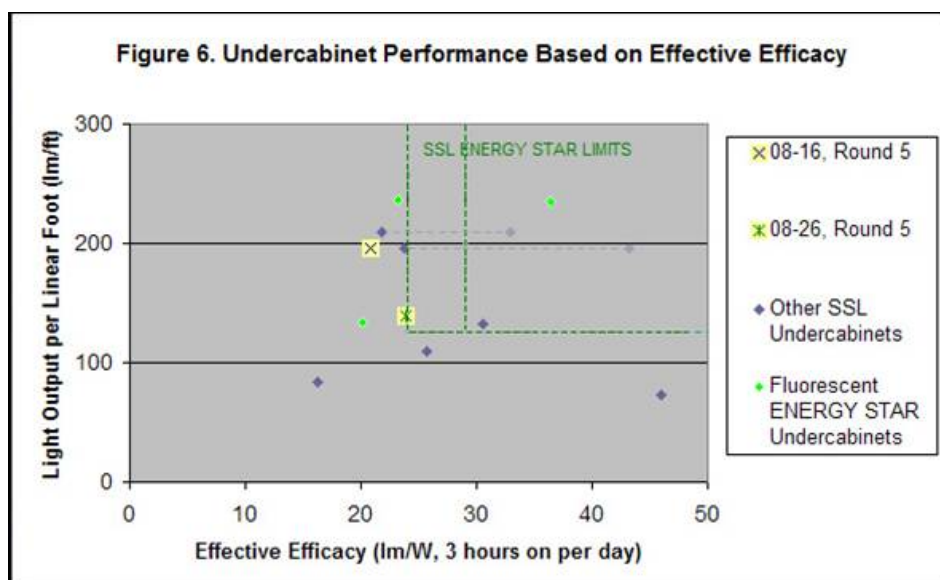
Testing includes basic photometry (following IESNA LM-79) using an integrating sphere and goniophotometry. *In situ* and lumen depreciation testing (following draft LM-80) are also conducted.



Attendees surround the CALiPER exhibit to learn more on LM-79 testing from Mia Page of PNNL.

CALiPER results are shared with manufacturers as a courtesy, before publication, and retesting options are available. DOE allows all CALiPER test results to be distributed in the public interest, for noncommercial, educational purposes only. Those who access the information must agree to a “No Commercial Use” policy, as the program goal is to inform industry and consumers, not to harm manufacturers.

Paget then presented an overview of all five rounds of testing, with an emphasis on Round 5, which included testing of recessed downlights, replacement lamps, task lights, and several outdoor applications. The results of all rounds vary widely. For example, performance of SSL T8-T12 linear replacement lamps was not yet competitive with fluorescent in output or efficacy. Testing also revealed misleading manufacturer literature, with the SSL replacement lamps emitting less than half the output claimed on spec sheets. MR-16 replacement lamps had variable results, also with inconsistent product literature (some SSL MR-16 products overstate output and efficacy). In the task lamp category, performance was tested in eight SSL undercabinet luminaires. Again, CALiPER testing revealed mixed results: the SSLs perform as well or better than the benchmark fluorescents in output and efficacy, but two luminaires draw off-state power and the light distribution is typically too narrow.



CALiPER Round 5 undercabinet lighting performance

CALiPER testing has improved market/industry awareness, resulting in improvements in SSL product literature, articles and discussions, and excellent preparation for ENERGY STAR. Paget noted that while “some products do perform well, most products on the market today don’t.” She advised the audience to understand and request SSL luminaire testing when evaluating SSL products.

In the Q&A session that followed, attendees asked why DOE does not publish a simple guide to make it easier for efficiency program managers to identify products that perform well. Paget noted that DOE is considering several new formats for disseminating CALiPER results to address this need but is moving carefully to meet the needs of end-users without alienating manufacturers. Additional discussion focused on sharing more details on accelerated lifetime testing and power factor.

To learn more about the DOE CALiPER test program, or to download CALiPER test reports, visit www.netl.doe.gov/ssl/comm_testing.htm.

7. Product Commercialization Issues

Fred Gordon of Energy Trust of Oregon, Inc., moderated the workshop session on product commercialization issues and barriers slowing widespread adoption of SSL.

7.1 NGLIA/DOE Initiative on Product Quality

Fred Welsh, Radcliffe Advisors

The lead-in speaker, Fred Welsh of Radcliffe Advisors, introduced the new SSL Quality Advocates Initiative, developed by DOE and the Next Generation Lighting Industry Alliance (NGLIA) to improve the quality of SSL products and prevent a recurrence of CFL market introduction mistakes. Initial efforts involve the development of guidelines for reporting product performance and a new Lighting Facts™ label, which was previewed for attendees.

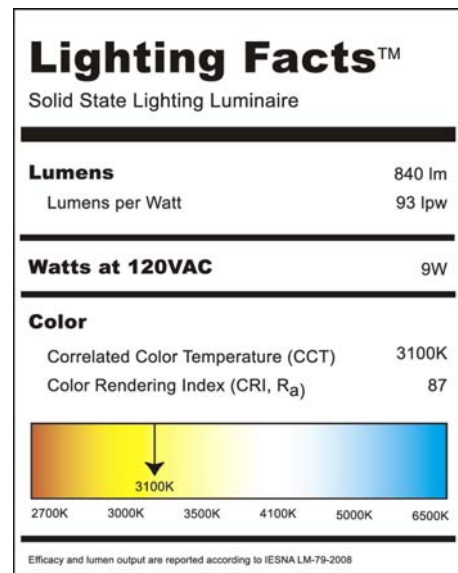
Welsh also introduced the Quality Advocates Pledge Program, to be unveiled in early 2009. The program is designed to build a growing community of SSL Quality Advocates throughout the supply chain who either agree to follow the guidelines and use the label, or to look for and use products that bear the label. The label is a “first action step” in the initiative toward improved quality performance.

As a voluntary product labeling program, the SSL Quality Advocates Initiative focuses on assuring that LED lighting products are represented accurately by:

- Defining a minimum set of performance parameters for reporting purposes
- Encouraging greater consistency in industry reporting of SSL performance through reference to standards and development of guidelines.

The Quality Advocates team has defined five critical parameters that should be part of an SSL product’s quality analysis: lumens, lumens per watt (efficacy), input power, correlated color temperature (CCT), and color rendering index (CRI). Both lumens per watt and total lumen output refer to the *luminaire* and must be measured using the new IESNA standard, LM-79-2008. These parameters and other recommendations are detailed in a new guide, *Reporting LED Luminaire Product Performance*. The guide also features the new Lighting Facts™. Similar to a nutrition label, the new label will provide a quick and simple summary of product performance data for five critical parameters.

To continuously improve SSL product quality, Welsh noted, additional metrics may be considered for future editions of the guide, related to reliability, product consistency, construction, or other



The Lighting Facts label, designed to go on the product, packaging, or literature, provides a simple summary of product performance data.

parameters. The team is also working on a companion guide with critical parameters and guidelines for light sources.

The Quality Advocates Pledge Program will enable the entire lighting community to participate and support quality SSL products. Participating manufacturers will sign a voluntary SSL Quality Pledge, agreeing to follow the guidelines and use the label, either on the product, product packaging, or product literature. “We are not telling manufacturers that they must operate at any particular level,” Welsh said. “We just want them to be clear about what their level is.”

Participating manufacturers in the initiative will benefit through:

- Public recognition as an SSL Quality Advocate and a technology leader dedicated to quality
- User confidence in the quality of products and the accuracy of program participants’ claims
- Enhanced customer satisfaction and accelerated market development.

Others in the supply chain – buyers, contractors, lighting designers, distributors, retailers, utilities, and efficiency organizations – may also become SSL Quality Advocates by pledging to support the initiative. These advocates promise to look for and use products from manufacturers who participate in the SSL Quality Pledge Program.

Welsh concluded by asserting again that accurate and consistent reporting of SSL product performance is the strongest foundation for reliable product quality and long-term buyer satisfaction. Encouraging the development of high-quality products that perform as claimed will help improve market acceptance – a lesson not soon to be forgotten from the ineffective early efforts to win customer approval for CFLs.

7.2 Building Bridges – Perspectives from the Lighting Designer Roundtable

Randy Burkett, Randy Burkett Lighting Design

Next, Randy Burkett of Randy Burkett Lighting Design reviewed perspectives and feedback from the March 2008 Lighting Designer Roundtable, held in Chicago. Hosted by DOE, the International Association of Lighting Designers (IALD), and the Illuminating Engineering Society (IES), the Roundtable was developed to solicit feedback from lighting designers on SSL market and technology issues.

Burkett reported that he and other designers at the Roundtable see a strong future for SSL as a design option, but he also cautioned that “specifiers should consider an SSL system’s strengths and weaknesses in each application, as you would for any other light source or luminaire.” In explaining what practicing lighting professionals think about SSL, Burkett posed some of the current questions they are pondering:

- Is anyone really specifying this stuff?
- Is this a technology that will have a permanent home in architectural lighting design?
- Does it hold as much promise for the profession as it is often reported?

“There’s already a lot of bad information out there,” Burkett stated, “so the more ammunition we can be given, the better.” Designers, he said, must “think design and functional excellence first, with the understanding of when and where SSL is an appropriate tool for the job.” He cautioned against “overestimating its charm or shortchanging it for its limitations,” adding, “You have to understand the strengths of a lighting source like this. In my view, white light LEDs are going to become the workhorses in some lighting applications.”



R-Sole retail shoe store uses SSL display lighting

Burkett presented a series of dazzling slides that demonstrated LED design applications of the present and future. Burkett stressed that while spectacular LED installations get noticed, designers are starting to consider LEDs for a wider range of applications, for both dramatic effect and workhorse functionality.

Burkett then discussed the DOE/IES Design Guide for SSL, unveiled in draft form at the Roundtable for review and comment. The Design Guide provides technical information on LED performance and design guidance for specific applications according to space and building type. It was developed to focus on marketable products, create a common vocabulary for specifiers and manufacturers, educate potential users about the good and bad, raise good questions for better results, and drive the market to improve the luminaires. The guide’s target audience includes

electrical contractors, design/build contractors, general specifiers, architects, product salespersons, and research and development specialists. The final version of the guide is expected to be issued by IES in late 2008.

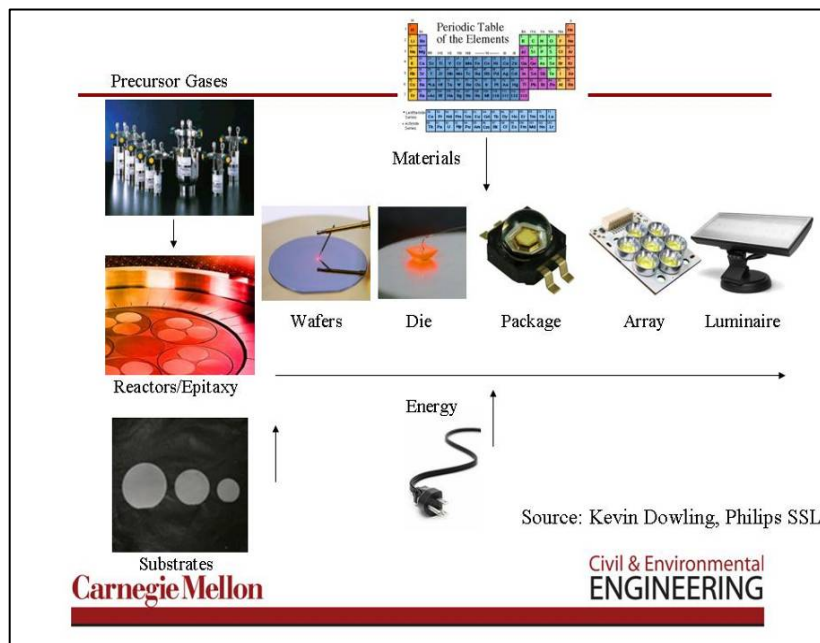
“When the Design Guide was presented to the participants at the Lighting Designer Roundtable,” Burkett stated, “we offered numerous comments and input – and this is exactly what DOE wanted. I find the Design Guide to be very well-rounded technically. This is a living resource to all of us that will grow and evolve.”

7.3 Environmental Study – Solid-State Lighting Life Cycle Analysis

Scott Matthews, Carnegie Mellon University

Scott Matthews, Research Director of the Green Design Institute at Carnegie Mellon University, concluded the Product Commercialization workshop session. Matthews presented an overview of the proposed methodology and approach for a new DOE study to look at energy and environmental aspects related to the manufacture, use, and disposal (or recycle) of SSL systems. Life cycle analysis is seen as an important tool for understanding how SSL will impact energy consumption, energy and product economics, pollution prevention, and environmental decision-making. Currently the study is in the planning stages, and Matthews invited attendees to provide input on relevant data sources and issues/concerns to address.

Energy and environmental considerations of SSL life cycle analysis



The motivation for the study is to ensure “no surprises” in terms of net energy, material hazards, or scarcity (none are anticipated), as well as to show the total benefits of this analysis in a systematic way.

“Life cycles may in fact last years,” Matthews commented, “from taking the raw materials out of the ground to end-of-product life and on to recycling and waste. Data sources are essential, encompassing company information, government information, and public information. It’s important to remember that our analysis is only as good as our data, and this can prove to be a significant barrier.”

The study will be performed in two phases. The first phase, slated to be completed this fall, will define the parameters of the study, including the identification of key energy and materials issues, the availability of relevant data, and a definition of the study’s scope and boundaries. Boundary issues for the analysis are an important consideration, including decisions on what parts of the life cycle will be included or excluded by default, as data

gaps are realized. Matthews will work with industry during this phase in both defining the parameters of the study and acquiring sources of data.

The second phase will encompass a comparison of solid-state lighting to at least several mature lighting technologies in both the residential and commercial markets. “We certainly are looking for collaborators,” he concluded, “not only to provide data but also to help validate the data we gather.”



Product Commercialization Session panelists address audience questions. Seated left to right: Fred Gordon, Energy Trust of Oregon; Fred Welsh, Radcliffe Advisors; Randy Burkett, RBLD; and Scott Matthews, Carnegie Mellon University.

During the question and answer session following the presentations, Randy Burkett was asked whether the spectacular nature of the “present and future” application visuals in his presentation represented less-than-favorable uses of the technology. Burkett replied, “The future of SSL lies in white light LEDs and using those in more mainstream lighting applications. Those images are essentially a good way to get the juices flowing in a dialogue about SSL, but in fact, I think that the future lies in what we can do with SSL in our standard toolbox.”

The remaining questions were addressed to Scott Matthews. The first questioner asked when Matthews expected to have the study done and to begin releasing results. Matthews responded, “In the next three to four months, we expect to have established the scope. The good thing about these kinds of analyses is that they can be presented in progress. I would expect that we could possibly start showing the first, preliminary results in about six months after we set the scope – a little less than a year from now.”

The next questioner asked Matthews how he will keep the study relevant, given that production efficiencies are continually changing over time. “This is certainly something we’re concerned about,” Matthews said. “Changes over time in production efficiencies are probably going to have a pretty dramatic effect on what sort of outputs the results of this study will show. The preliminary exploratory data we’ve looked at so far suggest that we’re already going to have a positive impact and good results showing energy in and energy out.”

Finally, Matthews was asked how he will manage to ensure he gets the right data to avoid potentially misleading output that may then receive undue attention. “Guarding against the complexities and uncertainties of certain ‘lightning-rod factors’ while keeping the study credible are issues,” Matthews answered. “The actual process of getting the data is not so hard; it’s what you do to model or allocate it. But there are good, credible previous studies we will look to, to inform our work on SSLs. The main concern I have is yes, you can write a 200-page report, with 199.5 pages that don’t draw negative attention – but that half page with a caveat discussion of data sensitivity or similar point will gain the most attention. I don’t know that there’s an obvious answer, except to follow the methods of previous credible studies.”

8. National Technology and Design Competitions

8.1 The *L Prize*TM Competition

James Brodrick, U.S. Department of Energy

Day 3 began with a session highlighting new national competitions that heighten awareness and adoption of high-performance SSL products. James Brodrick from DOE introduced the *L Prize* competition, launched at LIGHTFAIR® in May 2008. *L Prize* challenges industry to develop replacement technologies for 60W incandescent lamps and PAR 38 halogen lamps. Winners will be eligible for cash prizes, opportunities for federal purchasing agreements, utility programs, and other incentives.



The L Prize competition is designed to spur development of SSL products to replace two of today's most inefficient lighting sources: 60W incandescent lamps and PAR 38 halogen lamps.

Brodrick shared his insight on LED industry advances and technology potential – advances fueled in large part by the 51 current DOE-funded SSL projects. He stated, “It is clear that the aggressive *L Prize* targets will be achieved –the question is not ‘if,’ but ‘when.’”

Winning products must meet rigorous performance requirements, detailed in the competition requirements (see www.lightingprize.org/pdfs/LPrizeCompetition.pdf). Technical specifications have been established to ensure compliance with the 2007 energy legislation and include additional details for quality, performance, and mass manufacturing. Products will undergo a rigorous product evaluation process: performance and lifetime testing by independent laboratories, field assessments in collaboration with utilities and other partners, and stress testing under extreme conditions. The goal is to detect and address product weaknesses before market introduction and avoid problems with long-term market acceptance. Brodrick stated that partners will be taking the “surest, most effective route to big energy savings.”

Four California utilities were actively involved in the *L Prize* competition planning and execution: Pacific Gas and Electric Company, Sacramento Municipal Utility District, San Diego Gas & Electric, and Southern California Edison. Each signed a Memorandum of

Understanding (MOU) with DOE to show their intent to promote winning *L Prize* products. Efficiency Vermont and Nevada Power are the most recent *L Prize* partners* to join the wave of support, and Brodrick actively invited efficiency program partners in attendance to participate. Partners will be assured of product quality and reduced risk through intensive, thorough, reliable product evaluations. Partners agree to participate in product promotion, such as consumer information and incentives paid directly to manufacturers or to consumers.



Efficiency Vermont is one of the newest L Prize partners to sign on, agreeing to promote winning L Prize products. Pictured, left to right: Gabe Arnold, Efficiency Vermont; Gregg Ander, Southern California Edison; James Brodrick, DOE; and Mary Matteson Bryan and David Alexander, PG&E.

DOE is also seeking retailer partnerships on the local, regional, and national levels, as well as demonstrations and promotions with local homebuilders, commercial developers, hospitality chains, local governments, schools, and universities. For more information on becoming an *L Prize* partner, see www.lightingprize.org.

8.2 The Role of Utilities in Leveraging the *L Prize* Competition

Gregg Ander, Southern California Edison

Gregg Ander of Southern California Edison (SCE) continued the *L Prize* discussion by explaining how utilities play a part in leveraging the competition. Ander noted that California increased energy efficiency funding for 2009–2011 to \$3 billion, while increasing energy efficiency goals, which are now at 2.5 billion kWh per year statewide. However, Ander added that existing technologies won't take California to that goal, so the state has an aggressive continuum of programs in place to “goose” the system, from rebates and incentives to codes for appliances and buildings.

One of SCE's roles is to find good, new, and efficient technologies worthy of accelerating into the market. According to Ander, the energy impact for efficiency in lighting is huge – a total of 2,390 TWh, or 30% (717 TWh) – which is why more than 60% of SCE incentives go to lighting.

* Since the July 2008 Workshop, Wisconsin Energy Conservation Corporation (WECC) has joined, becoming the newest *L Prize* partner. The current list of partners may be viewed at www.lightingprize.org/partners.stm.

Utilities like SCE need products in their portfolio such as the *L Prize* competition will generate, but they cannot directly support manufacturer research and development. The DOE *L Prize* competition will enable SCE to support a promising new technology through *in situ* analysis, demonstrations, pilots, training, and performance assessments. This approach allows SCE to educate buyers on the technology, accelerate market introduction, and reduce the technology's costs. SCE will support the winning *L Prize* products through utility incentives, education, training, and outreach.

To Ander, the *L Prize* competition represents a major opportunity. SCE serves 12 million customers, all operating a large pool of inefficient incandescent lamps. *L Prize* partners will benefit from access to larger markets, with more buying power. Larger volume purchases encourage will lower product costs and increase the rate of market adoption. As Ander declared, "If it saves energy, we want to see it installed as fast as possible." For more on the *L Prize*, visit www.lightingprize.org.

8.3 Next Generation Luminaires™ Commercial Design Competition

Ruth Taylor, Pacific Northwest National Laboratory



Ruth Taylor of PNNL followed with a look at another new national design competition, *Next Generation Luminaires*. Modeled after the successful *Lighting for Tomorrow* design competition for residential lighting, *Next Generation Luminaires* will focus on LED

commercial luminaires. The goal of both competitions is to spotlight product manufacturers who are "getting it right" and to recognize and promote high quality, energy-efficient luminaires.

Taylor began by providing a brief update on the 2008 *Lighting for Tomorrow* competition, sponsored by DOE, the American Lighting Association (ALA), and the Consortium for Energy Efficiency (CEE). Initiated in 2004 with a focus on CFL fixtures, *Lighting for Tomorrow* added a solid-state lighting category for the first time in 2006 and competition sponsors may shift its focus to SSL only in 2009. For the 2008 competition, judging was completed in May, and the winners will be announced at the ALA Conference in September. More information is available at www.lightingfortomorrow.com.

The new *Next Generation Luminaires* competition is sponsored by DOE, IESNA, and IALD. The competition will feature two submission categories: market-ready luminaires and innovative prototype products.

The first category will include:

- ENERGY STAR Category A products (including downlights, undercabinet, and desk/task lights)
- General illumination products (including cove lighting, valance lighting, pendants, wall washers, wall sconces, accent lighting, refrigerated and non-

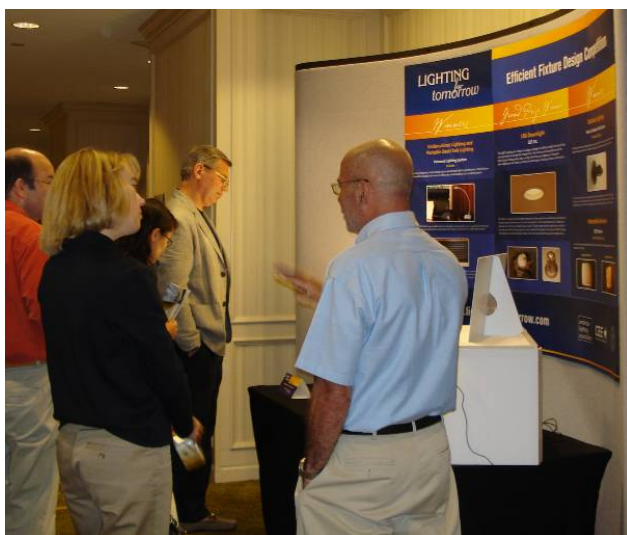
refrigerated retail case lighting, exterior architectural lights, street and area lighting, and pathway lighting).

The second submission category will address innovative prototype products that are not yet market-ready, including LED products integrated into furniture, equipment, or architectural elements.

Taylor next reviewed the product criteria, required documentation, online submission process, evaluation criteria, and timeline for the inaugural *Next Generation Luminaires* competition:

- Intent to Submit: August 2008
- Entries Due: October 2008
- Judging: November 2008
- Winners Announced: February 2009

More information is available at www.ngldc.org.



Kelly Gordon from PNNL addresses questions about the Lighting for Tomorrow and Next Generation Luminaires competitions.

In the Q&A that followed Taylor’s presentation, attendees asked for more details on the *L Prize*: how winners will be determined, if pricing is a consideration, if the competition has color temperature requirements. In his response, Brodrick stressed that the Competition Requirements document on the *L Prize* website specifies the performance and technical requirements in detail, including a request for pricing information and a business plan that demonstrates a company’s capability for mass production and delivery. See www.lightingprize.org for more details.

Responding to the question, “What is the actual prize?” Brodrick said that DOE will kick-start the prize fund, but the real prize is the large market potential the utility partners bring to the winners, along with the potential to sell to the federal government. The potential size of the 60W replacement bulb market – 3 billion sockets – was also discussed.

9. Preparing for SSL

9.1 A Utility Perspective – Designing Early SSL Incentive Programs

Mary Matteson Bryan, Pacific Gas and Electric Company

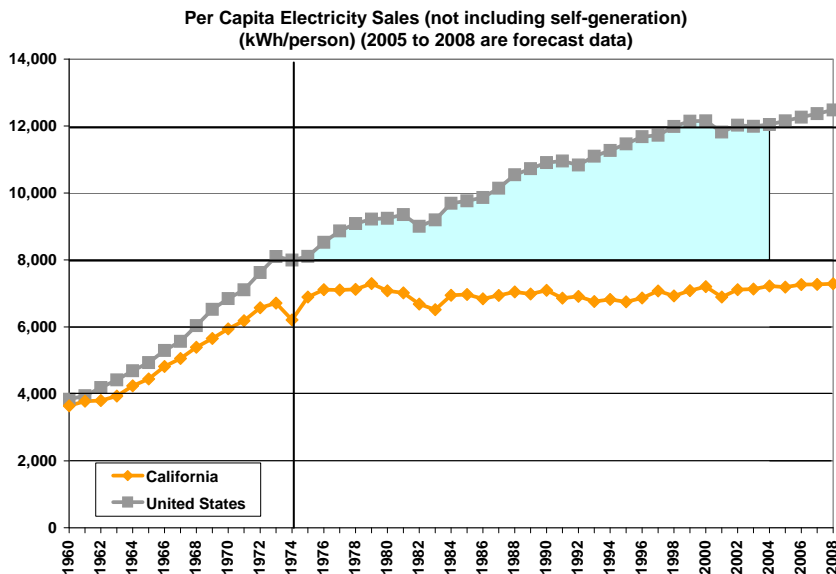
David Alexander, Pacific Gas and Electric Company

Session 6, moderated by Marc Ledbetter of PNNL, focused on what utility and efficiency program managers can do now to prepare for high-performance SSL products. Ledbetter applauded utility involvement and encouraged attendees to keep learning, because the technology is moving so fast that “anything you learn about SSL today may be out of date in six months.”



Dave Alexander, PG&E, Marc Ledbetter, PNNL, and Mary Matteson Bryan, PG&E, provide perspectives on assessing today's SSL products for incentive programs.

First, Mary Matteson Bryan and David Alexander, representing Pacific Gas and Electric Company (PG&E), explained the legislative and efficiency drivers for PG&E's interest in SSL. Most recently, the California Lighting Efficiency and Toxics Reduction Act has set aggressive goals: to reduce lighting energy consumption by 50% for residential indoor lighting, and 25% for commercial and outdoor lighting, by 2018. As the chart below indicates, while the rest of the country's energy needs have been on the rise, California has kept its per capita energy sales in check. This long-term focus on energy efficiency has enabled California to avoid building three new power plants.



Since 1974, growth in per capita electricity consumption in California has remained well below the national rate.

PG&E's Emerging Technologies Program identifies promising new technologies to accelerate market penetration. Field assessments evaluate energy savings and lighting characteristics. The results are published and used to support the development of incentive programs.

California Investor-Owned Utilities (IOUs) are developing LED lighting incentive programs using a standards-based approach (DOE ENERGY STAR and industry-standard test methods). The pilot programs will feature a high initial incentive level, which will be lowered as costs decline and the market matures. The product qualifying standards will be updated as technology advances. Currently, PG&E has planned incentives for refrigerated case lighting and recessed downlights, and is looking carefully at street and area lighting, parking garage lighting (a good application for achieving peak demand savings), and MR-16 lighting (probably the most requested incentive). According to Alexander, "New incentives are on the way for products that meet qualifying standards, which help to ensure customer satisfaction and persistent, reliable energy savings."

9.2 Efficiency Program Perspective – Designing Early SSL Programs

Gabe Arnold, Efficiency Vermont

Gabe Arnold of Efficiency Vermont presented perspectives from his statewide organization, which is charged with reducing electricity use and administering energy efficiency programs for 20 of 21 Vermont electric utilities. Arnold stated that Vermont is working to find a balance between caution and meeting market demands – his customers "cannot wait to try LEDs."

Efficiency Vermont carefully selects products for demonstrations, looking at CALiPER test results, LM-79 test data, product samples, and IES file data. He shared examples from a number of recent installations, including a deli, an auto dealer, and a retail restaurant chain, as well as a list of current products supported, including downlights, PAR and MR-16 replacements (spotlight applications only), outdoor fixtures, and refrigerated case lighting.



LED downlights in the Denecker Chevrolet showroom, Vergennes, Vermont

In 2009, Arnold anticipates implementing a full suite of incentives, following the DOE specification. They plan to move quickly and aggressively to promote good performing products and eligible product lists. According to Arnold, “The overarching goal is to ensure customer satisfaction and energy savings.”

9.3 Balancing Risks and Rewards – The Economics of SSL

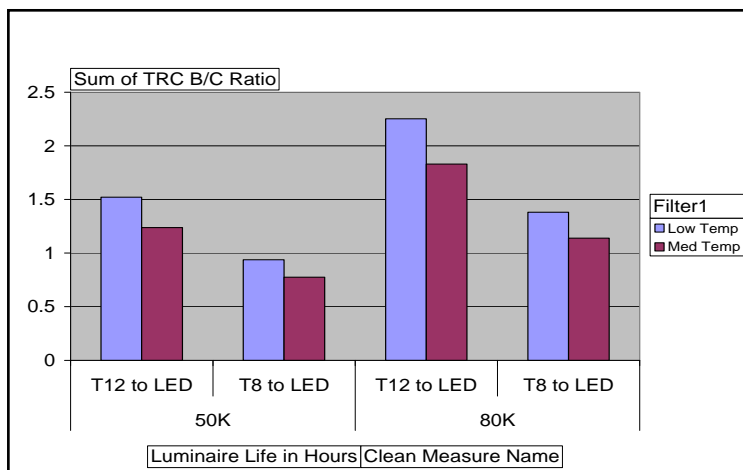
Charlie Grist, Northwest Power and Conservation Council

Charlie Grist of the Northwest Power and Conservation Council next discussed balancing risks and rewards, and shared an electric utility system perspective on the economic issues of implementing SSL technologies. Grist evaluated costs and benefits of several SSL technologies, comparing SSL to traditional sources on the basis of performance, cost-effectiveness, and “the unknowns.”

Grist suggested taking a Total Resource Cost (TRC) perspective, noting that for example, the state of Oregon buys “lighting” not just a “street light.” He recommended that TRC include energy use, capacity, line loss savings, deferred transmission and distribution (T&D), annual operation and maintenance costs or benefits, periodic replacement costs or benefits, space conditioning interactions, quantifiable non-energy costs or benefits, and risk-mitigation benefit. Grist urged attendees to look at the metrics, namely the present value of benefits and costs (TRC Benefit/Cost Ratio).

He noted that key inputs for consideration should include avoided costs, and recommended asking, “What will this technology do to total energy use?” He also suggested evaluating lighting power density, hours of operation, interactions with heating and cooling, and saturation of lighting. For SSL, the key economic considerations are high first cost, potential for long life, potential for more useful light, and potential for dimming and occupancy control.

Grist walked attendees through a quick cost/benefit analysis of several emerging SSL products and applications, including refrigeration display case lighting, which is highlighted in the chart below.



*Total Resource Cost (TRC)
Benefit to Cost Ratio for
refrigerated case lights*

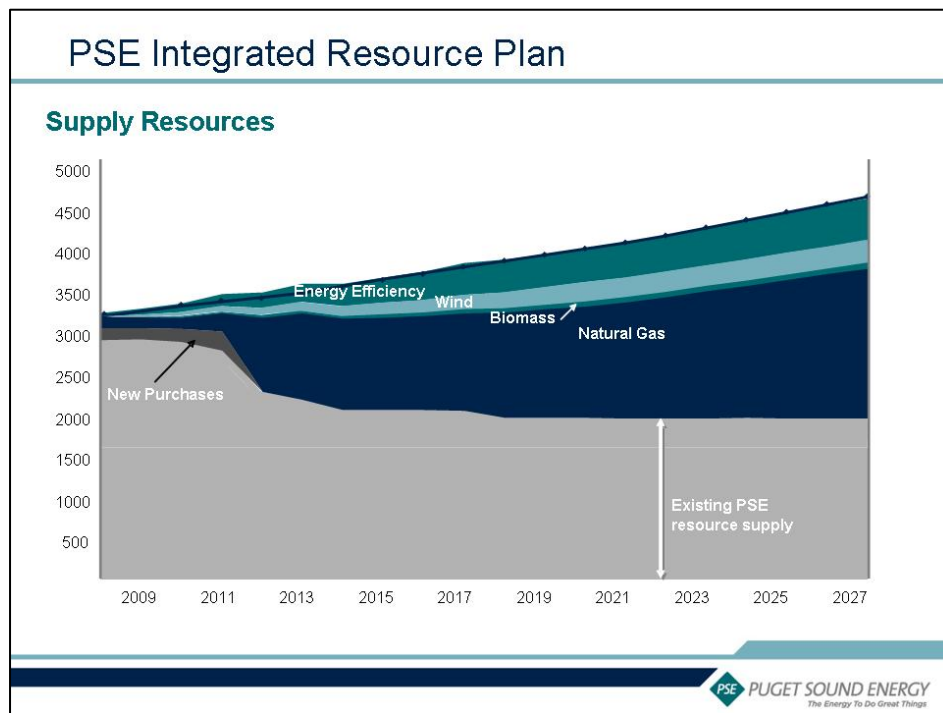
To conclude, Grist summarized that “mileage may vary” – costs and benefits must be carefully calculated, alternatives must be carefully considered, and that it is essential to “do your homework.”

9.4 Focusing on the Integrated Resource Plan

Todd Starnes, Puget Sound Energy

Todd Starnes of Puget Sound Energy (PSE) shared strategies the company uses to support new technology. PSE seeks out product applications with defensible (and enormous) cost-effective savings, and then utilizes its relationships with builders, retailers, vendors, and trade organizations to promote new products. Starnes noted that “the CFL gravy train is reaching the end of the line,” and new technologies like SSL are needed to meet PSE resource acquisition targets.

Starnes shared a look at PSE’s Integrated Resource Plan (below), which shows a marked drop-off in new supply resources by 2012 as long-term contracts come to a close.



PSE is deployment-oriented and seeks to move volumes of product into the market, and forecasts that the majority of its energy savings will come from residential customers. PSE supports new technology through a strict analysis and evaluation process. It has also streamlined the regulatory process by simplifying tariffs by housing type, which has accelerated the process considerably.

Starnes revealed a shift in how PSE views energy efficiency: the executive team sees energy efficiency and new technology as a way to gain visibility with customers and regulators. “Customers view green power and energy efficiency as the same thing,”

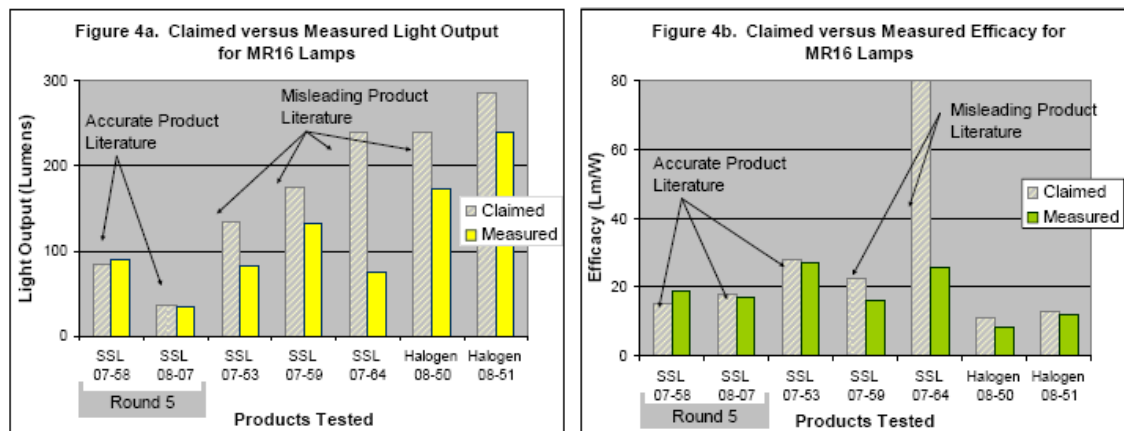
Starnes said. Consequently, this focus on customer behavior has enabled PSE to refine its marketing approach and increase its customer knowledge – understanding how they live, where they go for information, and what motivates their decisions.

9.5 Getting Ready for ENERGY STAR

Jeff Harris, Northwest Energy Efficiency Alliance

Jeff Harris of the Northwest Energy Efficiency Alliance (NEEA), a four-state regional collaborative, continued the session with a frank discussion about preparing for ENERGY STAR. He began by referencing the market confusion caused by the recent EPA release of RFL v4.2, an ENERGY STAR lighting specification in conflict with the DOE ENERGY STAR SSL specification v1.0, released in 2007. Harris stated, “NEEA will not recommend any incentives for residential SSL until this is resolved.”

Harris also expressed concern regarding the 100 ENERGY STAR partners, their 12,000 SKUs, and the fact that manufacturers are already claiming more than they are performing. He cited two figures (below) from the CALiPER Round 5 Summary Report, which compare claimed versus measured light output and efficacy for MR-16 lamps. CALiPER testing revealed that several MR-16 replacement products tested did not perform as well as their manufacturers claimed.



CALiPER Round 5 testing results on MR-16 lamps

Recalling his experience in the 1990s with CFLs, Harris noted that “we sold 250,000 bulbs that were heavy and that burned out – products that were not really ready for the market. We had to rethink our strategy.” For SSL, Harris recommended looking at what the market needs. He stated that SSL must go toe-to-toe with existing options, and in the northwest, the base product for comparison will be CFLs. Harris advised attendees to focus on incenting applications that take advantage of the unique properties of SSL, noting that street, area, and display case lighting may be the best near-term opportunities. He concluded by cautioning: “Don’t incent anything that would actually add load!”

9.6 Getting Involved with SSL: DOE's GATEWAY Demonstration Program and Registry

My Ton, Pacific Northwest National Laboratory

My Ton of PNNL closed Session 6 with an explanation of how utilities and efficiency organizations can get involved with DOE's GATEWAY demonstration program and registry. GATEWAY partners benefit from the shared opportunity to evaluate SSL product performance and gain experience with SSL daily operation. Demonstration teams typically consist of a product manufacturer, a host site, and an energy efficiency organization or local utility, with DOE acting as matchmaker and mentor for the teams. The idea is to assist in identification and early adoption of products that offer users real value through significant improvements over the current best competing products.

Ton reviewed the application process and DOE's methodology, which emphasizes product selection, team formation, product testing (using LM-79), field measurements, and evaluation and reporting of results. Results and reports are widely publicized by DOE to ensure that everyone can learn from each demonstration project.

Ton also unveiled plans for the development of a registry for GATEWAY and for "Do It Yourself" demonstrations. Once launched, the registry will be open to all parties wishing to access information and updates regarding ongoing and completed demonstrations. Parties wishing to conduct their own demonstrations can use the registry to access information on DOE demonstration methodology, download DOE's GATEWAY report template, and disseminate their demonstration results via the registry.

For third-party SSL demonstration results reporting via the registry, DOE will require the following information:

- Project evaluation
- Lighting measurements
- Control for external factors
- Evaluation of photometric data
- Qualitative lighting analysis
- Economic analysis

More details on the GATEWAY demonstration registry will soon be available at www.netl.doe.gov/ssl/techdemos.htm.

10. Next Steps

Moving forward, the U.S. Department of Energy will continue to work closely with the Solid-State Lighting industry, energy efficiency organizations, utilities, and standards organizations to guide market introduction of high-performance SSL products.

In September 2008, DOE will finalize preparations for the ENERGY STAR SSL program launch, issuing a manufacturer's guide and unveiling an online submission tool. For more details, visit www.netl.doe.gov/ssl/energy_star.html.

At the same time, DOE ENERGY STAR SSL program planning will continue with the release of draft criteria for additional categories of products for stakeholder review and comment. To learn more, visit www.drintl.com/temp/ENERGY_STAR_CAT_A_Additions_final.pdf.

Additional milestones and events in September include:

- Round 6 of CALiPER testing, covering numerous small replacement lamps (MR-16, A19-style, and other slightly larger A-lamp or PAR lamp replacements), as well as some outdoor fixtures, desk lamps, and an integral downlight.
- Detailed test reports and the Round 6 summary report, soon to be available on the DOE website at www.netl.doe.gov/ssl/comm_testing.htm.
- The anticipated release of IESNA LM-80, Approved Method for Measuring Lumen Depreciation of LED Light Sources. For the latest updates, visit www.netl.doe.gov/ssl/usingLeds/measurement-series-standards-performance.htm.
- Winners of the 2008 *Lighting for Tomorrow* design competition, to be announced at the ALA annual conference in Washington, DC, on September 16, 2008. For more information, go to www.lightingfortomorrow.com.
- An *L Prize* competition webcast, hosted by DOE, on September 23, 2008. Learn more about what to expect from winning *L Prize* products and what efficiency programs are doing now to prepare. To register for the webcast, visit www.netl.doe.gov/ssl/webcast-lprize.html.
- The final weeks for manufacturers to complete and submit entries for the *Next Generation Luminaires* competition. All entries are due by October 15, 2008, with winners announced in early 2009. For a detailed timeline and additional information, go to www.ngldc.org.
- Anticipated completion of several DOE GATEWAY demonstrations, including the unveiling of the St. Anthony Falls Bridge in Minneapolis, Minnesota, featuring LED roadway lighting. Additional information about the latest GATEWAY demonstrations is available at www.netl.doe.gov/ssl/techdemos.htm.

Finally, to stay apprised of DOE SSL program activities, progress, and events, register for ongoing updates at www.netl.doe.gov/ssl. Look for an SSL Update on the 2009 SSL Market Introduction Workshop, planned for July 2009 on the East Coast.

11. Appendices

APPENDIX A: Workshop Attendees

APPENDIX B: DOE SSL Program Fact Sheets

APPENDIX C: SSL Quality Advocates Initiative Materials

APPENDIX A: Workshop Attendees

DOE SSL Workshop: Portland, OR July 7–9, 2008

Attendee List

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Diane Allard
Akoya

Tim Allen
Ming Solar

Gregg Ander
Southern California Edison

Lynn Anderson
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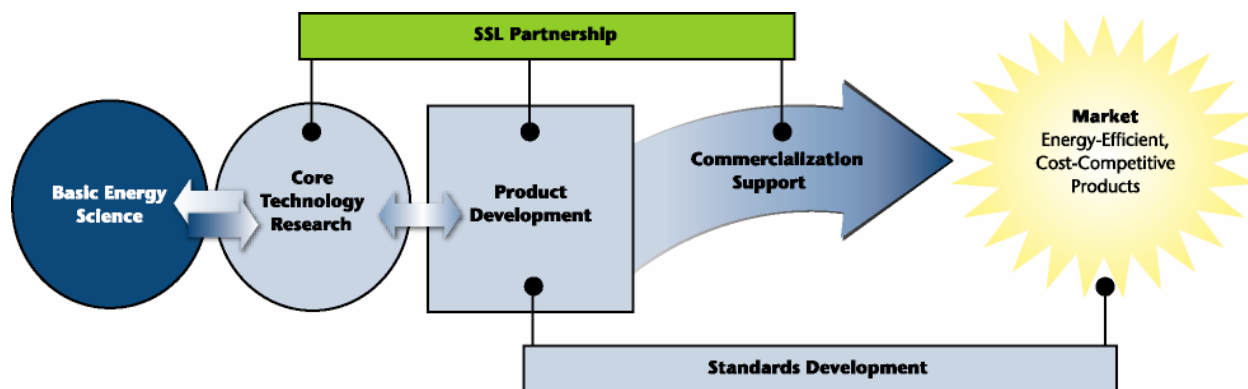
DOE Solid-State Lighting Portfolio

Guiding Technology Advances from Laboratory to Marketplace

The U.S. Department of Energy's solid-state lighting (SSL) portfolio draws on the Department's long-term relationships with the SSL industry and research community to guide SSL technology from laboratory to marketplace. DOE's comprehensive approach includes Basic Energy Science, Core Technology Research, Product Development, Commercialization Support, Standards Development, and an SSL Partnership.

Basic Research Advances Fundamental Understanding. Projects conducted by the Basic Energy Sciences program focus on basic scientific questions that underlie DOE mission needs. These projects target principles of physics, chemistry, and the materials sciences, including knowledge of electronic and optical processes that enable development of new synthesis techniques and novel materials.

DOE SOLID-STATE LIGHTING PORTFOLIO



- DOE's **Basic Energy Sciences** program conducts basic research to advance fundamental understanding of materials behavior. Project results often have multiple applications, including SSL.
- **Core Technology Research** projects focus on applied research for technology development, with particular emphasis on meeting efficiency, performance, and cost targets.
- **Product Development** projects focus on using the knowledge gained from basic or applied research to develop or improve commercially viable materials, devices, or systems.
- To ensure that these investments lead to SSL technology commercialization, DOE has drawn on its ongoing relationships with the SSL industry and research community to develop appropriate **Commercialization Support** strategies.
- In addition, DOE is working with the National Electrical Manufacturers Association (NEMA), the Next Generation Lighting Industry Alliance (NGLIA), and other standards setting organizations to accelerate the **Standards Development** process.
- The **SSL Partnership** provides input to enhance the manufacturing and commercialization focus of DOE's SSL portfolio.



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Core Technology Research Fills Knowledge Gaps. Conducted primarily by academia, national laboratories, and research institutions, Core Technology Research involves scientific research efforts to seek more comprehensive knowledge or understanding about a subject. These projects fill technology gaps, provide enabling knowledge or data, and represent a significant advance in our knowledge base. They focus on applied research for technology development, with particular emphasis on meeting technical targets for performance and cost.

Product Development Utilizes Knowledge Gains. Conducted primarily by industry, Product Development is the systematic use of knowledge gained from basic or applied research to develop or improve commercially viable materials, devices, or systems. Technical activities focus on a targeted market application with fully defined price, efficacy, and other performance parameters necessary for the success of the proposed product. Project activities range from product concept modeling through development of test models and field-ready prototypes.

Commercialization Support Activities Facilitate Market Readiness. To ensure that DOE investments in Core Technology Research and Product Development lead to SSL technology commercialization, DOE has also developed a national strategy to guide market introduction of SSL for general illumination. Working with the SSL Partnership and other industry and energy organizations, DOE is implementing a full range of activities, including:

- Testing of commercially available SSL products for general illumination
- Technology demonstrations showcasing high-performance products in commercial and residential applications and providing real-world experience and data on performance and cost effectiveness
- Technology procurement programs that encourage manufacturers to bring high-quality, energy-efficient SSL products to the market, and that link these products to volume buyers
- ENERGY STAR[®] designation for SSL technologies and products
- Design competitions for lighting fixtures and systems using SSL
- Technical information resources on SSL technology issues, test procedures, and standards
- Coordination with utility, regional, and national market-transformation programs

SSL Partnership Provides Manufacturing and Commercialization Focus. Supporting the DOE SSL portfolio is the SSL Partnership between DOE and the NGLIA, an alliance of for-profit lighting manufacturers. DOE's Memorandum of Agreement with NGLIA, signed in 2005, details a strategy to enhance the manufacturing and commercialization focus of the DOE portfolio by utilizing the expertise of this organization of SSL manufacturers.

The SSL Partnership provides input to shape DOE R&D priorities, and accelerates implementation of SSL technologies by:

- Communicating SSL program accomplishments
- Encouraging development of metrics, codes, and standards
- Promoting demonstration of SSL technologies for general lighting applications
- Supporting DOE voluntary market-oriented programs

Standards Development Enables Meaningful Performance Measurement. LEDs differ significantly from traditional light sources, and new test procedures and industry standards are needed to measure their performance. DOE provides national leadership and support for this effort, working closely with the Illuminating Engineering Society of North America (IESNA), NEMA, NGLIA, the American National Standards Institute (ANSI), and other standards setting organizations to accelerate the standards development process, facilitate ongoing collaboration, and offer technical assistance. New national standards and rating systems for SSL products began taking effect in early 2008.

June 2008

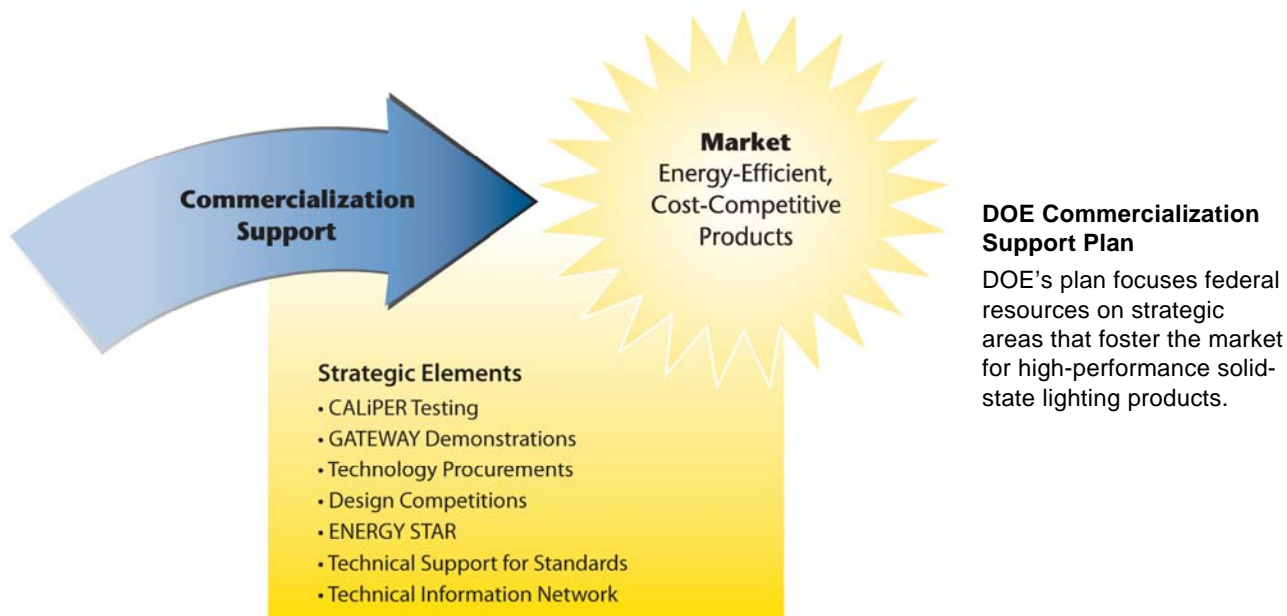
Guiding Market Introduction of High Efficiency, High Performance SSL Products

The U.S. Department of Energy (DOE) has developed a comprehensive national strategy to guide solid-state lighting (SSL) technology from lab to market. To leverage DOE's \$100 million investment in SSL technology research and development (R&D), and to increase the likelihood that this R&D investment pays off in commercial success, DOE has developed a commercialization support plan. The plan focuses DOE resources on strategic areas to move the SSL market toward the highest energy efficiency and the highest lighting quality.

DOE's plan draws on key partnerships with the SSL industry, research community, standards setting organizations, energy efficiency groups, utilities, and others, as well as lessons learned from the past. Commercialization support activities are closely coordinated with research progress to ensure appropriate application of SSL products, and avoid buyer dissatisfaction and delay of market development. DOE's role is to:

- Help consumers, businesses, and government agencies differentiate good products and applications
- Widely distribute objective technical information
- Coordinate SSL commercialization activities among federal, state, and local organizations
- Communicate performance targets to industry

DOE SSL PATHWAYS TO MARKET



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

DOE SSL Pathways to Market

CALiPER. Using test procedures currently under development by standards organizations, DOE's SSL testing program provides unbiased information on the performance of a widely representative array of commercially available SSL products for general illumination. Test results guide DOE planning for R&D, design competitions, technology procurement activities, and ENERGY STAR®, in addition to furnishing objective product performance information to the public and informing the development and refinement of standards and test procedures for SSL products. www.netl.doe.gov/ssl/comm_testing.htm

GATEWAY Technology Demonstration. Demonstrations showcase high performance LED products for general illumination in a variety of commercial and residential applications. Demonstration results provide real-world experience and data on state-of-the-art SSL product performance and cost effectiveness. Performance measurements include energy consumption, light output, color consistency, and interface/control issues. The results connect DOE technology procurement efforts with large-volume purchasers and provide buyers with reliable data on product performance. www.netl.doe.gov/ssl/techdemos.htm

Technology Procurement. Technology procurement is an established process for encouraging market introduction of new products meeting certain performance criteria. DOE has successfully used this approach with other lighting technologies, including sub-CFLs and reflector CFLs. Technology procurement will encourage adoption of new SSL systems and products that meet established energy efficiency and performance criteria, and link these products to volume buyers and market influencers.

Lighting for Tomorrow. In partnership with the American Lighting Association and the Consortium for Energy Efficiency (CEE), DOE sponsors *Lighting for Tomorrow*, a design competition that encourages and recognizes excellence in design of energy-efficient residential light fixtures. In the 2007 competition, 24 companies submitted 45 entries in the SSL category, with winning fixtures including a downlight, a desk lamp, an undercabinet fixture, and an outdoor wall lantern. www.lightingfortomorrow.com

ENERGY STAR for SSL. ENERGY STAR is a voluntary energy efficiency labeling program identifying products that save energy, relative to standard technology. Final ENERGY STAR criteria for SSL luminaires were released in September 2007, with an effective date of September 2008, contingent on related standards and test procedure finalization. www.netl.doe.gov/ssl/energy_star.html

Technical Support for Standards. LEDs differ significantly from traditional light sources, and new test procedures and industry standards are needed to measure their performance. DOE provides national leadership and support for this effort, working closely with the Illuminating Engineering Society of North America, the National Electrical Manufacturers Association, the Next Generation Lighting Industry Alliance, the American National Standards Institute, and other standards setting organizations to accelerate the standards development process, facilitate ongoing collaboration, and offer technical assistance. New national standards and rating systems for SSL products began taking effect in early 2008. www.netl.doe.gov/ssl/standards_dev.html

TINSSL. DOE's Technical Information Network for SSL increases awareness of SSL technology, performance, and appropriate applications. Members include representatives from regional energy efficiency organizations and program sponsors, utilities, state and local energy offices, lighting trade groups, and other stakeholders. The Northeast Energy Efficiency Partnerships and the CEE support DOE in this effort, collaborating with DOE to produce SSL information and outreach materials, host meetings and events, and support other outreach activities. www.netl.doe.gov/ssl/technetwork.htm

June 2008

CALiPER Program Supports Unbiased Testing, Promotes Consumer Confidence

Solid-state lighting (SSL) technologies are changing and improving rapidly as a growing stream of new products is introduced to market. Industry groups, standards setting organizations, and the U.S. Department of Energy (DOE) are moving quickly to develop and implement needed standards and test procedures for SSL products. At the same time, there is a need for reliable, unbiased product performance information in the dynamic early years of a developing market.

DOE's Commercially Available LED Product Evaluation and Reporting (CALiPER) Program (formerly the Commercial Product Testing Program) addresses that need. CALiPER test results guide DOE planning for R&D, technology demonstration, procurement, and ENERGY STAR® initiatives; convey objective product performance information to the public; and inform the development and refinement of standards and test procedures for SSL products.

Launched in October 2006, CALiPER supports testing of a widely representative array of SSL products available for general illumination, using test procedures currently under development by standards organizations. Guidelines for selecting products for testing ensure that the overall set of tests delivers insights across a range of lighting applications, product categories, and performance characteristics, a mix of manufacturers and devices, and variations in geometric configurations that may affect testing and performance. In addition, CALiPER testing measures variability across units and establishes benchmarking data with respect to other light source technologies and LED thermal management.

Testing Procedures and Methods

Products selected for the CALiPER Program are purchased and sent to qualified independent lighting testing laboratories. All luminaires are tested with both spectroradiometry and goniophotometry, along with temperature measurements (taken at the hottest accessible spots on the luminaire) and off-state power consumption. Standardized procedures are used for the tests, including the LM-79 standard for electrical and photometric measurement of SSL products, issued by the Illuminating Engineering Society of North America (IESNA) in April 2008.



Why CALiPER?

- Solid-state lighting is different from traditional sources.
- Existing standards and test procedures are not appropriate for evaluating SSL products.
- New standards and test procedures for evaluating LED-based luminaires (light source and fixture) are in development.
- CALiPER results help industry develop, understand, and implement a new way of testing.
- CALiPER results support DOE planning.
- Credible performance information is needed to avoid early buyer dissatisfaction and delay of market development.



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Manufacturers of tested products are given the opportunity to comment on test results prior to report completion. Testing results, summaries, and analysis are then distributed via the DOE SSL website. The Department allows its test results to be distributed in the public interest for noncommercial, educational purposes only. Detailed test reports can be requested by users who provide their name, affiliation, and confirmation of agreement to abide by DOE's "No Commercial Use" Policy.

Early Results

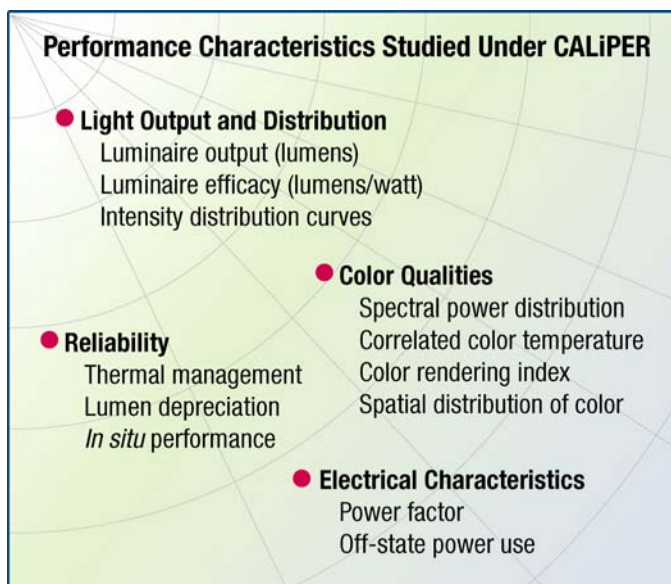
CALiPER testing to date has revealed a wide range of performance, from poor to excellent. Some SSL products tested deliver light output and efficacies that equal or exceed comparable incandescent and CFL products. Others perform poorly and do not produce enough light output for their intended application to be considered a suitable replacement for any similar product in use today.

The great divergence in applications and performance characteristics highlights the need for buyers to consider the performance of each product separately and to require clear and accurate luminaire performance information from manufacturers. While some manufacturers are publishing credible values for luminaire output and efficacy, there is often wide disparity between performance claims in marketing literature and actual tested luminaire performance. The need for reliable standards, credible testing, and accurate information—both for manufacturers and the public—is clear.

Next Steps

Ongoing CALiPER testing shows notable improvement in each round of testing, underscoring the significant potential of SSL and the rapid pace of technology advances. Luminaire manufacturers continue to integrate improvements in component efficiencies and new LED chips, which lead to improvements in overall luminaire efficacy and color quality. Underlying product characteristics will be strengthened by developing best practices for thermal management, good power quality profiles, and elimination of off-state power consumption. And as manufacturers become aware of the importance of assessing SSL luminaires on overall luminaire performance (i.e., testing of the entire luminaire, including LEDs, drivers, heat sinks, optical lenses, and housing), more reliable product performance information will emerge.

DOE and industry leaders will apply lessons learned to address concerns raised by the subset of products that are underperforming and/or featuring misleading performance claims. DOE anticipates this targeted effort will help pinpoint why some products are underperforming, enabling an industrywide focus on effective improvements in design and associated product literature.



For More Information

Web: www.netl.doe.gov/ssl/comm_testing.htm
Email: calipersupport@pnl.gov

May 2008

GATEWAY Demonstrations Showcase LED Product Performance

The U.S. Department of Energy (DOE) Solid-State Lighting (SSL) Technology Demonstration GATEWAY Program features high performance SSL products for general illumination in a variety of commercial and residential applications. Results provide real-world experience and data on product performance and cost effectiveness, and connect DOE technology procurement efforts with large-volume purchasers. Performance measures include energy consumption, light output, color consistency, and installation/interface/control issues.

How to Participate

The first “Invitation to Participate” was issued in March 2007. A second invitation followed in November 2007, and remains open through May 2008. DOE seeks to assemble demonstration teams that match host sites with appropriate products and partners. DOE GATEWAY demonstrations are open to all participants, subject to certain eligibility parameters. Demonstration teams typically include a product manufacturer, a host site, and an energy efficiency organization or local utility where applicable.

- **Manufacturers** provide products for demonstration and may assist in site selection and installation.
- **Host sites** provide locations for demonstrations, assistance with installation and evaluation/measurement, and a willingness to participate in demonstration-related activities such as tours and webcasts.
- **Energy efficiency organizations and utilities** provide contacts with potential host site organizations and assist with related outreach and promotional activities.

Potential participants are encouraged to submit expressions of interest using the application forms available at www.netl.doe.gov/ssl/techdemos.htm. Team members are not restricted to a single team or a particular project. A large hosting organization might demonstrate products from more than one manufacturer or a single manufacturer might participate with multiple products designed for different applications and locations.



*Demonstration in Oakland, California, with Beta LED streetlights (foreground) and HPS streetlights (background)
Photo: Beta LED*



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Sharing Results

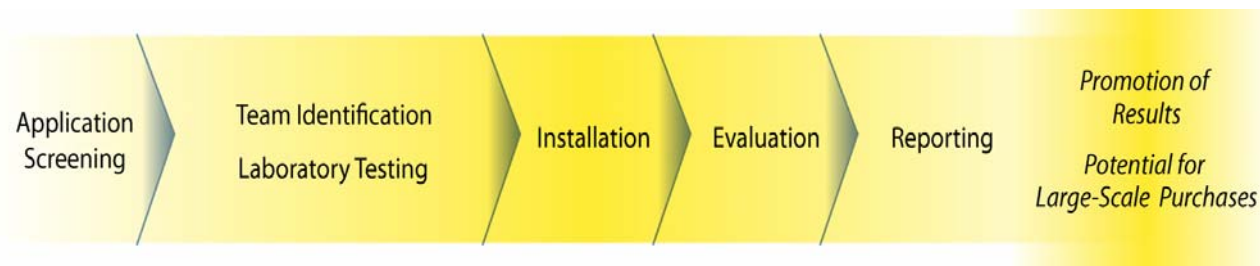
Results from DOE GATEWAY demonstrations enable participants to evaluate and refine their lighting requirements before making large-scale purchasing decisions. Demonstration project results are shared through the DOE SSL website, workshops, webcasts, and other demonstration-related activities.

DOE is also interested in working with team members, host site organizations, and other entities to form “user groups” to share information among users with similar needs. Participants in these user groups can join or initiate procurement efforts for high efficiency applications using information gained from demonstration projects, which can result in large scale purchases and/or promotion of featured products. More information on the formation of user groups will be posted on the DOE SSL website in 2008.

Other Ways to Participate

For parties conducting their own demonstrations and interested in widely sharing results, or for demonstrations already under way and wanting to access available resources, DOE is developing a Demonstration Checklist. Demonstrations meeting the Checklist requirements and/or developed using the Checklist may be able to access DOE support on a case-by-case basis. Successful demonstrations developed through this approach will be promoted via the DOE SSL website, events, and other appropriate venues and means. The Demonstration Checklist will be posted on the DOE SSL website in 2008.

DOE TECHNOLOGY DEMONSTRATION PROCESS



- **Initial Screening:** Applications are screened; prospective products and host sites deemed eligible are informed of their eligibility or asked for additional information.
- **Participant Team Identification:** Host sites and other team members are identified to carry out the actual demonstration of products.
- **Laboratory Testing:** Concurrent with team identification, testing of sample products is conducted to establish or verify important measures of performance.
- **Installation:** Products are installed with appropriate pre- and post-measurements; demonstration steps are carried out, including any publicity and education events.
- **Evaluation:** DOE’s Pacific Northwest National Laboratory evaluates the results, including energy and cost savings and related economic analyses, as well as qualitative occupant and user responses to the installed LED light source.
- **Results Reporting:** Results of successful demonstrations are widely publicized; results from long-term testing are released as they become available. While no sales of demonstrated products are assured, DOE expects large-scale product purchases or promotions by demonstration team members will also occur at this stage for products that have performed to buyers’ satisfaction.

For More Information

Web: www.netl.doe.gov/ssl/techdemos.htm

Email: techdemos@pnl.gov

May 2008



ENERGY STAR® Criteria for Solid-State Lighting Products

ENERGY STAR is a voluntary energy efficiency labeling program that establishes criteria manufacturers can use to promote qualifying products, guiding consumers in making informed decisions about products that save energy, relative to standard technology. Designed to set industry-wide specifications for solid-state lighting (SSL) products and to ensure the quality of all products bearing its mark, final ENERGY STAR criteria for SSL luminaires were released in September 2007, with an effective date of September 2008, contingent on related standards and test procedure finalization.



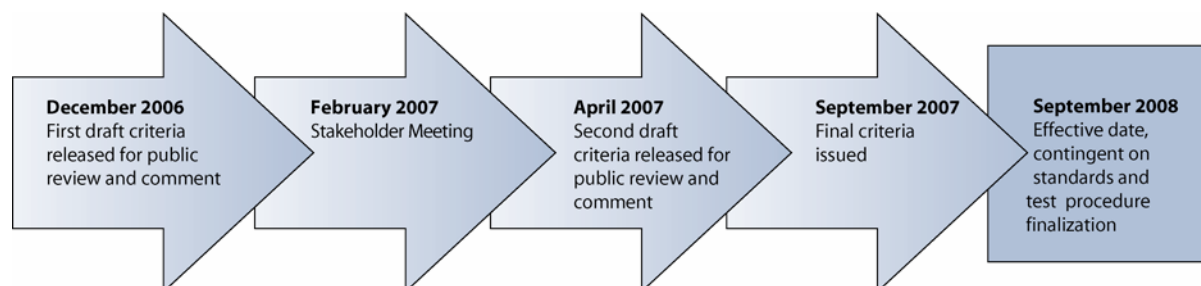
The ENERGY STAR label is a highly valued and widely recognized mark of energy efficiency, used by the American public to select cost-effective, energy-efficient products. As part of the Department of Energy's national strategy to accelerate market introduction of high-efficiency SSL products, DOE is leading ENERGY STAR management, specification development, and partner relations for SSL luminaires used for general illumination.



The ENERGY STAR criteria for solid-state lighting specify a transitional two-category approach.

- **Category A** addresses near-term applications, where SSL technology can be appropriately applied
- **Category B** establishes a future efficacy target for all applications, which will take effect once SSL technology improves

ENERGY STAR CRITERIA TIME LINE



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Category A covers residential, commercial, industrial, and outdoor lighting SSL applications of all types. This category includes near-term products such as undercabinet kitchen, undercabinet shelf-mounted task, portable desk/task, and recessed downlights for residential and commercial applications, outdoor wall-mounted porch, outdoor step, and outdoor pathway lighting. These lighting applications were chosen on the basis of their suitability for solid-state lighting, given the current state of the technology.

Category B covers innovative SSL systems applications of all types. This category encompasses a much wider range of future applications that will emerge as the technology matures further, and serves as a target for lighting manufacturers as they develop products over the next several years. SSL products will be able to qualify under Category B approximately three years after the effective date of the criteria.

At some point in the next three to five years, Category A will be dropped, and Category B will become the sole basis for ENERGY STAR criteria. This transitional approach recognizes the rapid pace of SSL technology developments, yet allows early participation of a limited range of products for directional lighting applications in Category A.

DOE intends to periodically review and amend the criteria to parallel technology advances and ensure that criteria remain up-to-date. For more information on DOE ENERGY STAR criteria for solid-state lighting, or to view the complete criteria, see www.netl.doe.gov/ssl/energy_star.html.

Key Partners in Criteria Development

DOE worked closely with key partners in developing the new ENERGY STAR criteria and the testing procedures upon which the criteria are based, including the Next Generation Lighting Industry Alliance (NGLIA), Illuminating Engineering Society of North America (IESNA), and American National Standards Institute (ANSI). DOE also received extensive advice and useful comments from individual lighting companies, electric utilities, energy efficiency organizations, and others.

NGLIA is an organization of U.S. lighting manufacturers, administered by the National Electrical Manufacturers Association (NEMA), which works with DOE to enhance the manufacturing and commercialization focus of the SSL portfolio. The Alliance provides input to shape research priorities, develop needed standards and test procedures, and support DOE voluntary market-oriented programs such as ENERGY STAR. More information about the Alliance is available at www.nglia.org.

General Requirements

The principal energy efficiency metric used in the criteria is luminaire efficacy (net light output from the fixture divided by the input power). Additional standards and test procedures necessary to address the nuances of SSL technology are currently being developed by IESNA, ANSI, and other organizations. In April 2008, IESNA completed the LM-79 standard for electrical and photometric measurement of SSL products, which specifies a standard test method for measuring the photometric properties of SSL devices, allowing calculation of luminaire efficacy. DOE anticipates additional related standards and test procedures will be completed by their respective organizations in 2008.

More details on the ENERGY STAR requirements and qualification process, along with application forms, will be available on the ENERGY STAR website in 2008. DOE will also issue periodic updates to stakeholders discussing implementation procedures, submittal dates, and marketing opportunities.

For More Information

Web: www.netl.doe.gov/ssl/energy_star.html

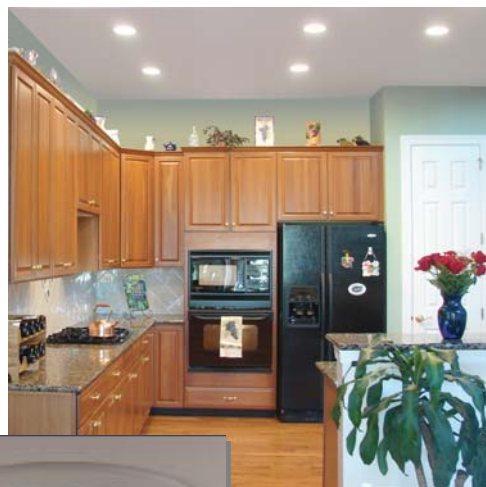
May 2008



Competition Recognizes Innovative, Energy-Efficient Residential Lighting Design

Lighting for Tomorrow encourages technical innovation and recognizes and promotes excellence in the design of energy-efficient residential lighting fixtures. Organized by the American Lighting Association, the U.S. Department of Energy, and the Consortium for Energy Efficiency, the design competition stimulates the market for attractive, energy-efficient residential lighting fixtures that use a fraction of the electricity of standard incandescent fixtures.

By encouraging manufacturers to develop the next generation of innovative, attractive – and energy-efficient – residential lighting fixtures, Lighting for Tomorrow increases market acceptance and awareness of the growing opportunities in energy-efficient lighting. The competition focus extends to marketing, promotion, and sales through primary distribution channels for both new construction and renovation markets. More than two dozen energy efficiency organizations in the U.S. and Canada pledge their support to the competition each year.



The LR6 downlight by LED Lighting Fixtures received the 2007 grand prize.

2007 Solid-State Lighting Winners

Lighting for Tomorrow was launched in 2002, with an initial focus on CFL fixtures. In 2006, a category for solid-state lighting was added, attracting 30 entrants. In 2007, two dozen companies submitted 45 solid-state lighting entries. Grand Prize Winner LED Lighting Fixtures Inc. (LLF) from North Carolina utilized LEDs in an innovative downlight that scored high marks for light output and color quality, with luminaire efficacy exceeding even the most efficient fluorescent downlights available today. California-based Finelite, Inc. won in the portable desk/task and undercabinet lighting categories. Progress Lighting, from South Carolina, won in the outdoor category with its Strata outdoor wall lantern. For more details or purchasing information on the winning products, visit www.lightingfortomorrow.com.



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Lighting for Tomorrow 2008

The 2008 Lighting for Tomorrow competition was launched at the Dallas Lighting Market in January 2008. Included this year is a new “Future LED” category that calls for use of the world’s most energy-efficient white LED devices. The 2008 competition categories include:

- **Near-term applications:** Undercabinet, portable desk/task, downlights, and outdoor porch/path/step lighting capable of meeting ENERGY STAR® criteria for solid-state lighting, Category A
- **Other applications:** Additional fixture types including wall sconces, table/floor lamps, pendants, and chandeliers, among others
- **Future LED showcase:** Fixtures that use the most energy-efficient, pre-production LED devices

Judging Criteria

Designs are evaluated on the basis of potential market impact, innovation, and functionality. Specifically in the LED category, judging criteria include lighting quality (color appearance, color rendering, illuminance levels, and distribution), application efficiency, thermal management, and aesthetic appearance.

Bonus points will be given for innovative designs that take advantage of unique LED attributes, fixtures eliminating off-state power consumption, indoor entries capable of dimming, and outdoor entries that are dark-sky friendly. Lighting for Tomorrow judges are drawn from across the lighting industry, creating a diverse panel of experts who sell, design, evaluate, and write about residential lighting design.

Timeline

The deadline for entries in the 2008 competition is April 30. Winners will be announced in September at the ALA Annual Conference in Washington, D.C. Winners gain further visibility and recognition as they are showcased at DOE and industry events, and in various publications. They also become eligible for promotion by energy efficiency programs across the U.S. and Canada.

For complete guidelines and rules for the 2008 competition, see www.lightingfortomorrow.com.

2008 Timeline

- January 2008: **Competition Announced**
- February 29, 2008: **Intent to Submit Forms Due**
- April 30, 2008: **Entries Due**
- May 2008: **Judging**
- September 14-16, 2008: **Winners Announced at ALA Annual Conference**

For More Information

Web: www.lightingfortomorrow.com
Email: LFT2008@pnl.gov

January 2008

Competition Recognizes Innovative, Energy-Efficient Commercial Lighting Luminaires

The Next Generation Luminaires (NGL) SSL Design Competition seeks to encourage technical innovation and recognize and promote excellence in the design of energy-efficient LED commercial lighting luminaires. Organized by the Department of Energy (DOE), Illuminating Engineering Society of North America (IESNA), the International Association of Lighting Designers (IALD), the competition encourages manufacturers to develop innovative commercial luminaires that are energy-efficient and provide high lighting quality and consistency, glare control, lumen maintenance, and luminaire appearance needed to meet specification lighting requirements.

Background

Since 2002, the US Department of Energy (DOE) has co-sponsored a national lighting fixture design competition (called Lighting for Tomorrow) in partnership with industry and energy efficiency organizations. The competition focuses on residential lighting, demonstrating that energy-efficient (fluorescent) lighting can be beautiful and decorative. In 2006, a LED category was added to Lighting for Tomorrow, to encourage well-designed residential LED luminaires in specific applications.

On-going advances in SSL technology and the growing number of product introductions signal an opportunity to encourage, recognize, and promote LED luminaires suitable for the commercial specification market, implicitly differentiating them from LED products that will not meet the needs of lighting designers, specifiers, and users.

Judging Criteria

Designs will be evaluated on the basis of color appearance, color rendering, appropriate illuminance and luminance levels, application efficiency, thermal management, and aesthetic appearance and style. Bonus points will be given for innovative designs that eliminate off-state power consumption, outdoor entries that are dark-sky friendly, and entries which address application modularity and serviceability/replacement issues.

Next Generation Luminaires judges will be drawn from across the architectural lighting industry, creating a diverse panel of experts who manufacture, design, evaluate, sell, research, and write about commercial LED lighting design.



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Submission Categories

Market-Ready Luminaires

The Market-ready category is for luminaires that are in or near production and ready for specification. Emphasis will be on quality and practicality of the luminaire for real-world lighting applications in the commercial specification market. Acceptable entries include but are not limited to: under-cabinet shelf-mounted lights, portable desk/task lights, recessed downlights, cove lighting, valence lighting, pendants, wall washers, wall sconces, accent lighting, refrigerated and non-refrigerated retail display case lighting, exterior architectural lights, facade lighting, street and area lighting, and pedestrian pathway lighting.

Emerging Products

The Emerging category encourages new, innovative ideas for application of white LEDs to solve lighting design problems. The category is open to products that are not yet market-ready, but a working prototype must be provided. Luminaires as well as LEDs and LED systems designed for integration into furniture, equipment, or architectural or structural elements are eligible.

For complete guidelines and rules for the 2008 competition, see www.ngldc.org.

2008 Timeline

- May 2008: **Call for Entries begins**
- July 31, 2008: **Intent to Submit Forms Due**
- September 26, 2008: **Entries Due**
- November 2008: **Judging**
- February 2009: **Winners Announced**

For More Information

Web: www.ngldc.org
Email: NGL08@pnl.gov

June 2008

REPORTING LED LUMINAIRE PRODUCT PERFORMANCE

*An Initiative for
Better Solid State Lighting*

Next Generation Lighting Industry Alliance
with the
U. S. Department of Energy



July 2008

REPORTING LED LUMINAIRE PRODUCT PERFORMANCE

A joint committee of the U.S. Department of Energy (DOE) and the Next Generation Lighting Industry Alliance (NGLIA) has undertaken an effort to assure and improve the quality of solid state lighting (SSL) products. This brochure on LED Luminaire Performance reporting is the initial outcome of that effort. The ultimate goal is to develop an expanded community of *SSL Quality Advocates* throughout the supply chain who are committed to support and implement continuous improvement of SSL product quality.

The rapid growth of SSL has resulted in an increasing number of new products on the market for various lighting applications. While many, if not most, of these are excellent introductions and showcase the energy-savings potential for SSL, quite a few under-performing products are also appearing in the market. Such products can discourage the early adopters of this new technology, significantly delay market penetration, and may thus disadvantage the entire industry. This situation also occurred in the early days of compact fluorescent lighting, inhibiting market acceptance of CFL products and negating significant potential energy savings in subsequent years.

To avoid, or at least reduce, this problem in emerging markets for solid state lighting, DOE urges manufacturers to agree, as a foundation of product quality, on accurate and consistent ways to report product performance, whether it be in laboratory studies, press releases, or manufacturer data sheets.

DOE and NGLIA recommend that a minimum set of critical parameters, described below, be reported by luminaire manufacturers to accurately reflect the performance of their products. While not formal standards or requirements at this time, ideally these recommendations would be uniformly adopted for LED lighting product sold in the United States. These recommendations currently apply only to LED lighting, and this document refers only to self-contained replacement lamps, light engines, and full luminaire products, not packaged LED devices.¹ Luminaire recommendations are intended to better inform designers, contractors, and other professionals about the performance they can expect from a lighting product and its suitability for the intended application. Some subset of these critical parameters, in a simplified form, may also be suitable for the retail market.

The initial five recommended parameters for performance reporting are:

- Luminaire efficacy
- Light output of the luminaire
- Measured input power
- Correlated color temperature
- Color rendering index

For enhanced quality, other metrics may be considered in the future, such as those related to reliability, product consistency, or construction. While standardization may make these recommendations obsolete, it is often sufficient simply to ensure that results are completely and consistently reported and accompanied by adequate background information to allow buyers to make a fair comparison among the products available for purchase.

¹ For definitions of the various SSL product levels, please refer to ANSI/IESNA RP-16-05 Addendum a, "Nomenclature and Definitions for Illuminating Engineering," May 2008.

LUMINAIRE PERFORMANCE METRICS

Reported component-level measurements are, with a few exceptions, adiabatic or nearly so; that is, they are taken over a short interval so as not to appreciably change the temperature of the LED chip during the measurement. As a result, component-level performance figures are generally optimistic and may differ significantly different from those that would be obtained under normal operating conditions.

Manufacturers of luminaires should insist on good component specifications, including thermal performance and lifetime characteristics, from their suppliers, but should also be aware that this information is not sufficient to describe the finished product. One of the most common misrepresentations of luminaire product performance is simply reporting the device performance without accounting for the influence of driver and luminaire design.

The following recommended parameters apply to all embodiments of LED products that include a driver—the “Lamp” and “Luminaire”—but manufacturers must use care in comparing lamp measurements to full luminaire results. Luminaire measurements, unlike component-level measurements, have generally been standardized with the issuing of IESNA Standard LM-79-2008. It is important to note that this standard specifies *absolute* photometry.

Luminaire Efficacy (*Lumens per Watt*) is a specific measure of the net useful light output from the luminaire for a given power input. Properly measured, Luminaire Efficacy combines both the light source system efficacy and luminaire efficiency, allowing for a true comparison of a luminaire regardless of the light source. Luminaire efficacy is the preferred metric for LEDs because it measures the net light output from the luminaire divided by power into the system, accounting for driver, optical, and thermal losses. Methods for measuring luminaire efficacy of solid state lighting fixtures and lamps are defined in the IESNA standard, LM-79-2008.

Reported efficacy values for a given product can vary greatly depending on how light output and power use measurements are taken. For example, light output could be measured from a light source alone, from an entire luminaire, or within a specific test area. Input power could be specified alternatively as into the light source alone, into a ballast plus source, into a power supply with driver electronics, or at the 120 VAC wall plug. The energy-efficiency community has traditionally compared light sources based on system efficacy, rated lamp lumens divided by power into the system that includes source and driver. This doesn’t work for LEDs because there are no standard LED lamp packages or lamp ratings, and, perhaps most importantly, because LED performance depends on the thermal, electrical, and optical design of the system or luminaire.

Light Output of Luminaire is the total lumens output by a luminaire (as a whole). For SSL products, luminaire light output must be determined by measuring the output of the entire luminaire (including the LED device, thermal management, fixture, and optics) in an integrating sphere or goniophotometer using absolute photometry.

Measured Power is the total power consumed by a luminaire measured in Watts. In all cases, the luminaire power should be measured upstream of power supply/driver. For example, for a luminaire that includes a wall plug, the measured power is at the wall socket input. For a luminaire wired directly to 120 VAC, the measured power is at the 120 VAC input.

Correlated Color Temperature (CCT) for an SSL luminaire ideally should be determined through integrating sphere testing of the whole luminaire. If this test result is not available, the CCT value for the

LED device used in the luminaire can be reported, but reports must indicate that the CCT value was measured at the LED device level. The CCT of the luminaire may differ from the CCT of the device for any of several reasons:

- Operating currents and temperatures can affect the color temperature of an LED device.
- Reflective surfaces or a translucent enclosure on the fixture can change the CCT.
- An array of LED sources may include multiple devices with different CCT values.

Ideally, both Color Coordinates in the CIE 1931 x,y Chromaticity diagram and Correlated Color Temperature (CCT in degrees Kelvin) should be reported, because there can be confusion about what CCT means, especially if the coordinates are well off the Planckian locus.

Color Rendering Index (CRI) should be measured according to the standard R_a method used for conventional sources. As with other measurements, the CRI should be measured for the luminaire in normal steady-state operation to account for any effects of temperature or luminaire design on color.

AN INVITATION TO JOIN SSL *QUALITY ADVOCATES*

This brochure is the first step in an ongoing effort to enhance the quality of SSL products. The DOE is developing a pledge program to expand the community of *SSL Quality Advocates* committed to quality improvement. Luminaire manufacturers who join agree to add a simple *Lighting Facts*TM label to the product, packaging, or accompanying literature specifying the minimum parameters. Similar reporting recommendations will soon be available for source manufacturers. Other *SSL Quality Advocates*, including those who purchase or specify, agree to ask that their suppliers adhere to these recommendations. Please watch DOE's SSL website for forthcoming information on how your company can participate by taking the *SSL Quality Pledge*.

Lighting FactsTM

Solid State Lighting Luminaire

Lumens 840 lm


Lumens per Watt 93 lpw

Watts at 120VAC 9 W

Color

Correlated Color Temperature (CCT) 3100 K

Color Rendering Index (CRI, R_a) 87



2700K 3000K 3500K 4100K 5000K 6500K

Efficacy and lumen output are reported according to IESNA LM-79-2008

The Lighting FactsTM label provides a quick and simple summary of the critical parameters for a luminaire described in this brochure.

Solid State Lighting Quality Advocates

Take the Voluntary SSL Quality Pledge

The rapid growth of solid state lighting (SSL) has brought many new lighting products to the market. Most are excellent introductions and showcase the energy-savings potential for SSL. But some, unfortunately, misrepresent their performance.

Poor or misrepresented products can discourage the efforts of early adopters of the new technology, significantly delay market penetration, and may disadvantage the entire industry.

As a foundation of product quality, the DOE urges manufacturers to voluntarily report a consistent set of performance metrics in a clear and simple format. For luminaires, the metrics include lumen output, luminaire efficacy, power input, color temperature, and color rendering index.

Lighting accounts for about 25% of energy consumption in commercial buildings and 12% of residential energy consumption. SSL can potentially save half of lighting energy, making it an attractive near-term opportunity.

Benefits of the voluntary reporting program include:

- Acceleration of market development
- Enhancement of customer satisfaction
- Differentiation of quality and performance leaders in a new lighting technology.

The SSL Quality Pledge is a voluntary agreement by LED luminaire and source manufacturers and others in the lighting value chain to support the performance reporting initiative. Taking the pledge establishes a manufacturer as an industry leader in support of high quality products for next generation lighting. Others — including but not limited to buyers, contractors, lighting designers, distributors, retailers, utilities, and efficiency organizations — may also become an SSL Quality Advocate by pledging to support the initiative.

Achievements of SSL Quality Advocates will be recognized and publicized. Other agencies, states, utilities, universities, and trade associations are publicly recognizing corporate efforts in reducing energy use.

The pledge form on the reverse side of this document is specifically for manufacturers of luminaires or replacement lamps. Pledges for LED device manufacturers and others will be available soon on the DOE SSL website, www.netl.doe.gov/ssl.

What Is the SSL Quality Pledge?

The **SSL Quality Pledge** is a joint effort of the Department of Energy (DOE) and the Next Generation Lighting Industry Alliance (NGLIA) to assure and improve the quality of solid state lighting products.

Lighting Facts™

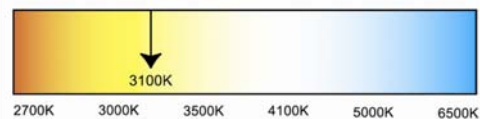
Solid State Lighting Luminaire

Lumens	840 lm
Lumens per Watt	93 lpw

Watts at 120VAC	9 W
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Color

Correlated Color Temperature (CCT)	3100 K
Color Rendering Index (CRI, R _a)	87



Efficacy and lumen output are reported according to IESNA LM-79-2008



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

SSL Quality Pledge

Voluntary Pledge for Luminaire Manufacturers

_____ voluntarily agrees to become an **SSL Quality Advocate**.
(Company Name)

We pledge to support improved quality of LED solid state lighting products.

- As a **luminaire manufacturer**, we agree to provide clear and consistent reporting of essential performance, measured with agreed SSL standard methods, in the following categories:
 - Lumen output
 - Luminaire efficacy
 - Power input
 - Correlated color temperature
 - Color rendering index.
- Critical information will be readily available on product packaging or literature.
- We will provide feedback on product performance parameters and statistical sales information for monitoring purposes. (Results will be aggregated to protect proprietary information.)

The Department of Energy will:

- Continue to drive technology development through the SSL R&D program, including support for work related to product quality and reliability
- Continue a variety of initiatives designed to support market introduction, including testing and demonstration programs, information and education through the SSL website, and other vehicles
- Monitor the accuracy of reported performance, on a sampling basis, through its CALiPER testing program
- Publicize accomplishments and results of the SSL Quality Advocates.

The Department of Energy enters into this Agreement under the authority of the section of 106 of the Energy Policy Act of 2005 (Pub. L. No. 109-58, 42 U.S.C. § 15811). This Agreement in no way restricts any of the Parties from participating in any activity with other public or private agencies, organizations, or individuals. This Agreement is neither a fiscal nor a funds obligation document. Nothing in this Agreement authorizes or is intended to obligate the Parties to expend, exchange, or reimburse funds, services, or supplies, or transfer or receive anything of value. This Agreement is strictly for internal management purposes of each of the Parties. It is not legally enforceable and shall not be construed to create any legal obligation on the part of either Party. This Agreement shall not be construed to provide a private right or cause of action for or by any person or entity. All agreements herein are subject to, and will be carried out in compliance with, all applicable laws, regulations, and other legal requirements. Companies, plants, or other non-Federal signatories agree that they will not claim or imply that their participation in the SSL Quality Pledge that the Federal government approval or endorsement of anything other than its commitment to energy efficiency and will not make any statements or imply that DOE endorses the purchase or sale of products and services or the organization's view.

On behalf of _____, the undersigned company representative understands and agrees to the terms of the *SSL Quality Pledge*.

Signature: _____ Position: _____

Printed Name: _____ Date: _____

DRAFT June 2008